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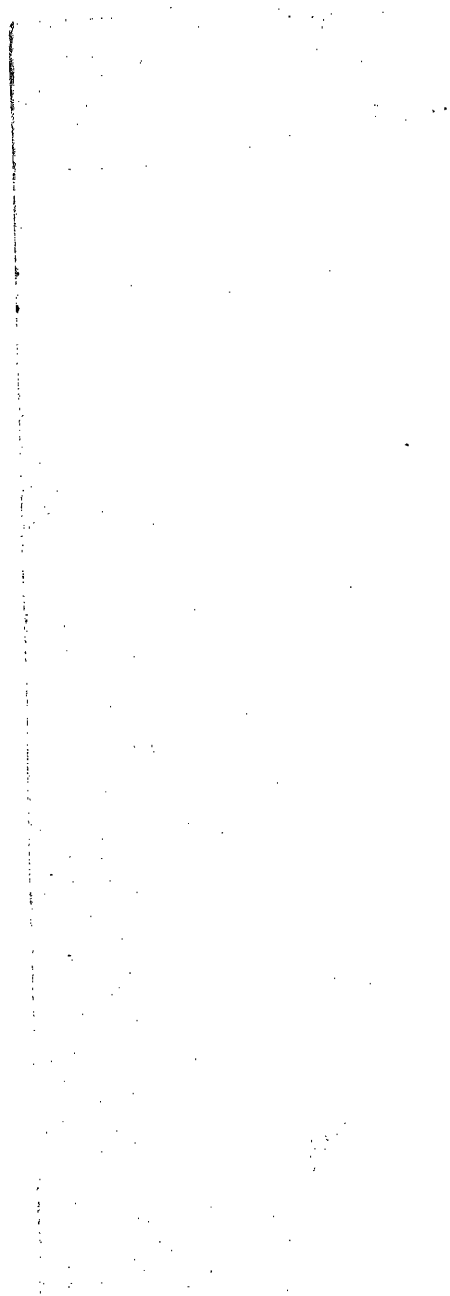
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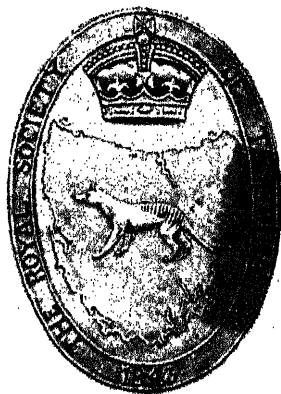
THE ROYAL SOCIETY  
OF  
TASMANIA



PAPERS & PROCEEDINGS  
OF  
THE ROYAL SOCIETY  
OF TASMANIA

FOR THE YEAR

1929



(With 31 Plates and 20 Text Figures)

ISSUED 19th MARCH, 1930

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1930

The responsibility of the statements and opinions in the following papers and discussions rests with the individual authors and speakers; the Society merely places them on record.

## THE ROYAL SOCIETY OF TASMANIA

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The Royal Society of Tasmania was founded on the 14th October, 1843, by His Excellency Sir John Eardley Eardley Wilmot, Lieutenant Governor of Van Diemen's Land, as "The Botanical and Horticultural Society of Van Diemen's Land." The Botanical Gardens in the Queen's Domain, near Hobart, were shortly afterwards placed under its management, and a grant of £400 a year towards their maintenance was made by the Government. In 1844, His Excellency announced to the Society that Her Majesty the Queen had signified her consent to become its patron; and that its designation should thenceforward be "The Royal Society of Van Diemen's Land for Horticulture, Botany, and the Advancement of Science."

In 1848 the Society established the Tasmanian Museum; and in 1849 it commenced the publication of its "Papers and Proceedings."

In 1854 the Legislative Council of Tasmania by "The Royal Society Act" made provision for vesting the property of the Society in trustees, and for other matters connected with the management of its affairs.

In 1855 the name of the Colony was changed to Tasmania, and the Society then became "The Royal Society of Tasmania for Horticulture, Botany, and the Advancement of Science."

In 1860 a piece of ground at the corner of Argyle and Macquarie streets, Hobart, was given by the Crown to the Society as a site for a Museum, and a grant of £3,000 was made for the erection of a building. The Society contributed £1,800 towards the cost, and the new Museum was finished in 1862.

In 1885 the Society gave back to the Crown the Botanical Gardens and the Museum, which, with the collections of the Museum, were vested in a body of trustees, of whom six are chosen from the Society. In consideration of the services it had rendered in the promotion of science, and in the formation and management of the Museum and Gardens, the right was reserved to the Society to have exclusive possession of sufficient and convenient rooms in the Museum, for the safe custody of its Library, and for its meetings, and for all other purposes connected with it.

In 1911 the Parliament of Tasmania, by "The Royal Society Act, 1911," created the Society a body corporate by the name of "The Royal Society of Tasmania," with perpetual succession.

The object of the Society is declared by its Rules to be "the advancement of knowledge."

His Majesty the King is Patron of the Society; and His Excellency the Governor of Tasmania is President.



# THE ROYAL SOCIETY OF TASMANIA

## PAPERS AND PROCEEDINGS, 1929.

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**PAPERS**  
**OF**  
**THE ROYAL SOCIETY OF TASMANIA**  
**1929**

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FLINDERS, BAUDIN, AND BROWN AT ENCOUNTER  
BAY.

By

R. W. GIBLIN, F.R.G.S., F.R.E.S.

(Read 13th May, 1929.)

One of the great events in the early history of Australia took place when the English explorer Captain Flinders met the French explorer Captain Baudin in Encounter Bay, near Kangaroo Island, South Australia, on the 8th April, 1802. The meeting was a dramatic one in several ways. The countries of the two sea-captains were as they believed at war with one another. Baudin, if he had any inkling of Flinders's voyage, certainly had no previous knowledge of his movements and now learnt for the first time that the coast lying ahead of him had been explored and charted by his "opposite number." In Flinders's case one element of surprise was lacking, for he had knowledge of the French expedition before he left England, but he now discovered to his satisfaction that he had not been forestalled by the other in the survey of a great part of the southern coast of Australia.

The encounter, therefore, was one that might easily have proved at least formal, stiff, and even hostile, although each leader was provided with a passport from the enemy Government. On the contrary it turned out to be quite friendly, mutually accommodating and instructive. The two interviews that took place when Flinders visited the Frenchman in his ship the *Géographe* on the 8th April and again on the following morning have often been discussed and described, notably so in Professor E. Scott's *Terra*

*Napoléon*, and in the same author's *Life of Matthew Flinders*. The sources of information are the narratives provided by Flinders and by François Péron, the naturalist on board the *Géographe*, and in addition, as the result of more recent research, that of Baudin. There is another account of those most interesting interviews, that of Robert Brown, the botanist, one of Flinders' staff in the *Investigator*, who accompanied his chief as interpreter on the visits paid to the French commander. I have not been able to discover if Brown's notes, called by him "Miscellaneous Memoranda," have ever been published, but even if they have appeared before they have apparently attracted little notice and are worth reprinting. Apart from their value as a contribution to the general history of Australia they furnish a few items of special interest to readers of Tasmanian history. They are written on some sheets of rough note-paper sewn together, and are to be found in the British Museum, Natural History Department, South Kensington.

By courtesy of Dr. A. B. Rendle, M.A., F.R.S., Keeper of Botany, facilities were afforded me to copy these Notes, and permission to publish them, as well as those dealing with Robert Brown's visit to Port Dalrymple, was kindly granted by the Trustees of the British Museum.

#### MISCELLANEOUS MEMORANDA.

"April 8—1802.

About half past 4 o'clock P.M. saw a sail close in with the land nearly a head she was then standing towards us & in about an hour she passed close under our lee.

She proved to be the French frigate *Le Géographe* commanded by Cap<sup>n</sup> Baudin.

I accompanied C Flinders on board her & remained with C Baudin about  $\frac{3}{4}$  of an hour.

April 9<sup>h</sup>. Again accompanied C Flinders on board *Le Géographe* & staid about an hour.

From what fell from C Baudin in conversation it appeared that he had made the West coast of New Holland nearly where D'Entrecasteaux had commenced his survey & had run along great part of the West coast. He mentioned Shark's Bay in which he had been, & pointed out a mistake of Dampiers concerning an Island wch that navigator had laid down in his Sharks bay but which according to C

Baudin does not exist, he supposes Dampier might have been deceived by banks which are uncovered at low water.

C Baudin mentioned something about Rosmary Islands but from the extreme badness of his English I could not well comprehend what, it appeared to me however that he had not visited them.

During his course along the west coast he anchored thirty times.

From the west coast he appears to have gone to Timor where from circumstances mentioned he must have made some stay. There he lost 12 seamen & the Gardener from Dysentery.

From Timor he appears to have proceeded to Van Diemens land the southern extremity and east coast of which he examined several corrections of former charts he pointed out to C Flinders. I do not however distinctly remember them in one case his survey seemed to be inaccurate, viz in the Derwent where he had laid a bar with scarce one foot of water across the river whereas at this place C Flinders found at one side a channel with 2 fathoms, & in the river above 3 & 2 fathoms. The officer who made the survey had left the boat at the bar & walked along the bank of the river just as far as it appeared C Flinders had gone with his boat.

According to C Baudin every navigator who has visited Van Diemen's land has mistaken Tasman's Bay of Frederick Henry in proof of which he appealed to the Voyage of Tasman & a small chart of the bay by him.

On the east coast of Van Diemen's land he lost his best Boat, in which was the Geographer & 7 or 8 seamen she had been sent on an extensive survey of this part of the coast & C Baudin after remaining on the coast 8 days despairing of her return had then left it.

He appears however still to have considerable hopes of her not being lost & thought it probable she might have gone to Port Jackson.

He seems to have run along the north coast of Van Diemens land & before he new (*sic*) C Flinders's name, praised the accuracy of his Chart of this part of the coast but that taken from Mr. Bass he pronounced very faulty especially between Cape Wilson & Western Port & observed it was not executed by a seaman, judging I suppose from the great inaccuracy of the Latitudes given. He did not see

the large island mentiond by Mr. Reid commander of the colonial schooner at the N W coast of Van Diemens land.

He was not in Port Dalrymple. He appears also to have run along the north side of Bass's streight but not to have found any Port. He did not go into Western Port, deterrd as it would seem by finding only 6 fathoms a league from the entrance, if I understood him well however of wch I am by no means confident he had sent in his boat.

From his leaving the streight to the time of our meeting 21 days had elapsd during wch he had run along the intermediate coast without finding any bay or anchorage and having seen but one or two bights of no great consequence.

He parted company from *Le Naturaliste* in the streight. When we met his intention was to run along the supposed unexplord part of the coast & then return & put in to Port Jackson.

Each of the ships on leaving France (had) 10 naturalists on board six of those belonging to *Le Géographe* and among them Michaux were left at the Mauritius, whether *Le Naturaliste* kept all her number still I did not learn.

The Gardener of *Le Géographe* whom C Baudin mentioned with respect & whom he frankly pronounced a much better Botanist than the Gentleman at the head of this Department died as has already been observd at Timor. C Baudin informd us that he had found out where David Nelson was buried & had his Gardener interr'd beside him erecting a little monument with an inscription to the memory of both.

C Baudin informd us that a very considerable collection of natural curiosities had been made & if I mistake not said that he had on board about 100 boxes of these. I saw no living plants on board. A row of flower pots which stood in his own cabin were filled with earth but none of them seemd to contain any plants.

C Baudin showd us coloured figures of the natives of Van Diemens land they appeared to be characteristic but not well executed.

There were figures of their huts, of their tombs, & of their canoes. The canoe is exactly similar to that given by Billardiére.

All the natives were painted with woolly hair & C Baudin on being questiond on this head assur'd us that it was really so. The hair of all the figures was of an ochry

red in all probability from the ochre with which they colour their whole bodies. This substance together perhaps with a kind of calcareous marl which it is not unlikely they use may have given the woolly appearance to the hair—it seems at least extremely improbable that the natives of New Holland should have merely curled hair while their more southern neighbours in other respects exactly resembling them so as to leave little doubt of their being the same race should have the wool of the negro.

The charts which we saw were finished & coloured but C Flinders thought that in their general appearance at least they were rather below mediocrity."

#### COMMENTARY.

These notes of the botanist who in after years became so famous give occasion to a few comments on their contents, and perhaps the first thought of a general reader would be that they furnish a further confirmation, though none is now indeed, of the falsity of François Péron's statement that the explorers in the *Géographe* saw and noted Port Phillip and the entrance to it. A new point will be noticed by those who have studied the proceedings of Baudin's expedition with attention. The navigator did not sail into Western Port, but Brown gathered that a boat had been sent in. If that was so the visit, judging by Baudin's time table, could have been purely a perfunctory one, though some slight pause must have occurred to enable it to be carried out. Baudin appears to have been misunderstood by Brown in connection with the length of time taken by the *Géographe* to reach Encounter Bay after she left the "Streight." Twenty-one days before the meeting took place Baudin was at Waterhouse Island. It may be that he was referring to what is now known as Banks Strait.

Brown, to our loss, be it said, as the present account and other records of his prove, was a man of considerable reserve, one who failed, shall we say, to give expression to any views he may have formed of the personalities and characteristics of those men with whom he came in contact during his travels in Australia and Tasmania. Outside his purely scientific investigations it sufficed him to note facts only, and even then in a dry, sparing way. But perhaps it pleased him to be able to record what Baudin had to tell about the death of Anselme Riédélé, chief-gardener, at Timor; how he had discovered the grave of David Nelson,

the botanist of the *Bounty*, buried the French scientist nearby, and raised a monument with a suitable inscription in memory of the two men who had fallen by the way, struck down by ill-fortune when working for the advancement of knowledge. The incident reminds us of that occasion when in far-off Petropavlovsk La Pérouse paid a somewhat similar tribute to the memory of Captain Clerke in 1787.

Coming now to those items more immediately connected with Tasmania that had their place in the conversations between the three men in the cabin of the *Géographe*, it is a little surprising that the shallow areas of the Derwent well above Risdon should have formed a subject of discussion. The matter was after all a trivial one, but we can well understand that the question of the true position of Tasman's Frederick Henry Bay came to the front insistently, for Baudin could correctly claim credit that his work had solved a long-outstanding problem. The French commander showed himself in a well-disposed and neighbourly mood when he exhibited to his guests the coloured drawings of the natives of Van Diemen's Land, the sketches of their huts and tombs and canoes, and even the charts that had been executed. We may assume, I suppose, that the drawings displayed on that occasion are amongst those that were afterwards reproduced and published in the *Book of Illustrations* issued in Paris about the time that Péron's first volume concerning the voyage made its appearance. The same remark may be made with regard to the charts, about which Flinders expressed to Brown an unfavourable opinion.

As the host, and with some noteworthy results of the efforts of his expedition to show to his visitors, it is not to be wondered at that Baudin "held the floor" while entertaining them. Flinders recorded the fact that Baudin was more inclined to give than to receive information, though he did learn something from the Englishman about the chances of obtaining much needed food and water in the vicinity of the spot where they were conversing. Flinders's opportunity to show some of his own work to the French captain came three months later at Sydney.

Robert Brown called his notes Memoranda. They were evidently written soon after the interviews had taken place, and they show the variety of subjects that came up for discussion during the hour and three-quarters in all that he and his chief spent on the *Géographe*. We may be grateful for the things that his memory preserved for our benefit.

NOTES ON THE GENUS *PORIA*.

No. 3.

By

L. RODWAY, C.M.G.,

and

J. BURTON CLELAND, M.D.

(Read 13th May, 1929.)

THE AUSTRALIAN PORIAS AND PORIA-LIKE FUNGI  
WITH HYPHÆ NOT DEEPLY COLOURED.

## CONTINUED.

The present paper concludes our provisional attempt to disentangle the Australian species of the genus *Poria* and is continued from No. 2, published in these Papers and Proceedings, 1928, pp. 73-86. We are still left with a number of specimens, some probably representing other species, which time and further material may enable us eventually to define. The Australian specimens subjected to our revision have all been those in our own collections.

Owing to slipping of the type having rendered obscure the sub-headings of our section IV. in the Key, we re-submit this Key, published in our last part, completed by the addition of the species now discussed and lettered under major and minor sub-headings so as to prevent ambiguity.

## KEY.

## IV. Hyphæ not deeply coloured.

A. *Merulius* or *meruloid*.

- a. *Merulius*, sterile surface extensive, curling up at edges, whitish, reticulations flesh colour, pale tan or ochraceous tawny .. 18. *Merulius corium*
- a. *Meruloid*, variable, richly coloured (vinaceous cinnamon to brown) ... .. 19. *Poria merulina*
- a. *Merulius*, pure white with tendency to brownish discoloration, pores very shallow, orifices rather large ... .. 20. *Merulius candidus*



## A. Irpiciform.

Cinnamon drab to vinaceous drab, when old dark violaceous grey, edges villose to almost byssoid  
21. Resupinate forms of *Polystictus (Irpea) versatilis*

- A. Pore mouths relatively large, 0.5 mm. or more, edge determinate, colour pallid buff . . . . .  
. . . . . 22. *Poria subserpens*

- A. Plants more or less brightly coloured with pink, scarlet, orange, or apricot.

- a. Definitely vinaceous pink . . 23. *Poria vinaceo-rosea*

- a. Scarlet to salmon orange . . . 24. Resupinate forms of *Trametes (Polystictus) cinnabarinus*

- a. Apricot-coloured (capucine buff, capucine orange), thin, orifices readily recognisable to naked eye . . . . . 25. *Poria Archeri*

- a. Orange-tinted (warm buff, ochraceous buff, paler than capucine orange) including subiculum, relatively thick (up to 4 mm.), sometimes stratosed . . . . . 26. *Poria subaurantiacus*

- A. Sterile edge white, contrasting with the brown (Verona brown, warm sepia, bone brown, army brown) pore surface . . . . .  
. . . . . 27. Resupinate forms of *Polyporus dichrous*

- A. Tawny Olive. 28. *Poria*-like forms of *Trametes protea*

- A. Spores brown, 8 to 10 x 6.5 to 7  $\mu$ , pores dark brown, up to 2.5 mm. deep, sterile edge dirty whitish often with tints of orange, causing a dry rot . . . . . 29. *Poria incrassata*

- A. Spores white, large, 13 to 15 x 4.5 to 6.5  $\mu$ , usually abundant, plants buff to clay colour, sterile edge white or whitish, variable, sometimes with raised edges, pores usually very oblique . . . . . 30. *Poria macrospora*

- A. Spores white, usually abundant, oval or elliptical, 6 to 9 x 4 to 7  $\mu$ . Cutting like firm cheese when fresh, often with a phosphorus smell, usually inside burnt trunks, creamy-white becoming brownish, hyphae thick, soon attacked by insects, spores 6 to 7 x 4 to 6  $\mu$ . . . . . 31. *Poria dictyopora*

- A. Firmer, whitish to light buff becoming brownish, determinate, often extensive, not specially attacked by insects, spores thick-walled, 6.5 to 9.5 x 5.2 to 7.5  $\mu$ . . . . . 32. *Poria medulla-panis*
- A. Hyphæ very broad, up to 7.5  $\mu$ ., very irregular, thick-walled, plants white with a cinereous tinge, up to 5 mm. thick . . . . . 33. *Poria Wakefieldii*
- A. Corky-tough, rather thick (2 to 5 mm.), pallid to pale buff, rather soft to the touch, pores usually oblique, stratose, orifices 4 to 7 in 1 mm. . . . . 34. *Poria subcrassa*
- A. Pores rather large, 2½ to 3 in 1 mm., shallow, becoming snuff-brown, margin whitish, smooth, separating . . . . . 35. *Poria westraliensis*
- A. Buff tints distinct.
  - a. In parts at least definitely irpiciform. Indeterminate, pinkish buff, light ochraceous buff or cinnamon buff, orifices usually 0.2 to 0.4 mm. wide, readily recognisable to naked eye . . . . . 36. *Irpea obliquus*
  - a. Orifices regular, true *Poria*. Indeterminate, pinkish buff or cinnamon buff, edge paler, orifices 3 to 6 in 1 mm. . . . . 37. *Poria selecta*
- A. Pinkish buff to buffy whitish, orifices minute.
  - a. Edge white becoming smooth, orifices 7 in 1 mm. . . . . 38. *Poria minutipora*
  - a. Edge like pore-surface or paler, orifices 5 in 1 mm. . . . . 39. *Poria carneo-lutea*
- A. Pores sub-hyaline in appearance, whitish to dingy whitish to ochraceous buff, orifices 4-8 in 1 mm. . . . . 40. *Poria hyalina*
- A. Hard, chalky white to light buff, indeterminate, intimately adherent, orifices minute, about 6 in 1 mm. . . . . 41. *Poria calcea*
- A. Purplish to vinaceous drab in parts, elsewhere often pale buff to tawny olive, pores at first meruloid, indeterminate . . . . . 42. *Poria purpurea*
- A. Vinaceous flesh colour usually present, when thick throughout the substance, when thin often shades of cinnamon with paler edge, thin to thick, orifices minute, 6-11 in 1 mm. . . . 43. *Poria vinota*

- A. Pallid ochraceous, becoming ochraceous salmon and finally dark near Burnt Umber, tubes up to 2 mm. deep, orifices about 6 in 1 mm. . . . . 44. *Poria attenuata*
- A. On the ground and rotting logs, white turning brown in drying, rarely pileate, pores oblique, spores globose, 4 to 5  $\mu$ . . . 45. *Polyporus adiposus*

32. *Poria medulla-panis* (Pers.), Fr.—Additional notes. On section the pore-surface usually presents a pallid brownish appearance. We have several collections from Tasmania which agree with the mainland forms though the characteristic spores were not found. Tasmania.—Cascades near Hobart, May, 1925, and August, 1918; National Park, January, 1928 (section of pore-surface white). Specimens collected at the National Park in January, 1928, differ from our other specimens in the substance on section being a darker brown (near Wood Brown, XL.); the pore surface is like N.S.W. specimens, but the plants are thicker (nearly 1 cm.) and the characteristic spores were not seen.

34. *Poria subcrassa*, n.sp.—Forming adherent patches up to 7.5 x 4 cm., rather thick (2 to 5 mm.), Pale Pinkish Buff to Pinkish Buff (XXIX.), Light Buff (XV.) or approaching Warm Buff (XV.), corky-tough, usually rather soft to the touch, pores stratose, usually forming most of the substance, sometimes with a thin context layer. Pores often oblique, orifices 4 to 7 in 1 mm., dissepiments rather thick, setulose. Hyphæ rather wavy and somewhat varicose, 2 to 3.5  $\mu$ ., usually about 2.5  $\mu$ ., spores not seen. Tasmania.—Cascades, November, 1919 (type), July, 1919; Mt. Nelson, July, 1919, and two other collections without localities. The species approaches *P. medulla-panis*, Pers., and *P. pulchella*, Schw., which is sometimes considered a thin variety of the former (*vide* Bourdot et Galzin). It differs from Australian specimens of *P. medulla-panis* in being usually rather soft to the touch and thicker, the pores more frequently oblique, the orifices reaching to a smaller size and the absence of the abundant oval spores of *P. medulla-panis*.

35. *Poria westraliensis*, n. sp.—Forming sharply defined patches, 8.7 x 1.8 cm. or less, with edges separating from the substratum, nearly membranous, with a broad smooth sterile margin which is whitish with a slight buffy tint. On this the shallow pores develop, becoming near Snuff Brown

(XXIX.), rather large,  $2\frac{1}{2}$  to 3 in 1 mm., regular, dissepiments thin, not setulose. Hyphæ pallid, thick-walled, 3 to 4.5  $\mu$ . Spores not seen. W.A.—Pemberton, August, 1926.

36. *Irpeex obliquus* (Schräd.), Fr.—Rea in his *British Basidiomycetes* gives *I. obliquus* without any synonym and states that it is common. Under *Poria mucida* (Pers.), Fr., he gives = *Irpeex obliquus* (Schräd.), Fr., and says that *P. mucida* is uncommon. Bourdot et Galzin (Hyménom. de France in Bull. Trimestr. de la Soc. Mycol. de France, XLI., 1925, p. 237) under *Poria mucida*, Pers., give *Irpeex deformis*, Fr., *I. obliquus* (Schräd.), Fr., and *I. paradoxus* (Schräd.), Fr., as varieties.

This is a common and variable Australian species. Until identified for us by Miss Wakefield as *Irpeex obliquus*, we had placed it under *Poria*, to which we feel that it more properly belongs. Anyone examining a series of specimens of it, as we have done, without knowing its name, would be inclined to place it under *Poria*, and the young mycologist will here search for it.

We have fortunately had a large amount of material, over 50 collections, at our command. Otherwise we might have failed to realise the degree of variation that exists and have inferred that we were dealing with several species. Some that we have excluded may perhaps be only extreme variants, not separate species. The species is one that must certainly possess many synonyms.

With us it is found growing on the rough bark of many of our Eucalypts and on fallen branches, bark, and wood. When growing vertically, the irpicoid arrangement is clearly shown, and as the majority of specimens are in a more or less vertical position, the irpeex form of the plant is a common one. Sometimes on the underside of a log it grows horizontally, and then it would be classed as a *Poria*, though even thus the pore mouths are rather plate-like and jagged. Amongst our specimens, chiefly collected in New South Wales and S. Australia, we find that in addition to the irpicoid and poria forms, what appears to be the same species may sometimes grow on a rough uneven surface as little projecting knobs, and the pore mouths on these knobs may show a labyrinthiform or fluted arrangement with the dissepiments defective in places. This is evidently merely a growth form and not a variety, as normal growth and the labyrinthiform knobby one, or a labyrinthiform arrangement without knobs,

may occur on the same piece of wood. The colour also varies somewhat in depth and we have established a variety which is clay-coloured.

We describe the irpicoid form as met with in Australia as follows:—Colour deeper than Pinkish Buff (XXIX.), approaching Cinnamon Buff (XXIX.), or Light Ochraceous Buff (XV.) passing into Cinnamon Buff, when young whitish, creamy white, or pallid, deepening in colour on drying, irregularly effused with an indefinite felted sterile edge of the same colour or slightly paler, rarely whitish, not readily separable from the substratum, punky-friable, often many inches in extent and sometimes with outlying scattered masses. Thickness up to 1 mm. Pore mouths about 0.2 to 0.4 mm., occasionally 0.5 to 0.7 mm. and once 1.25 mm. wide when growing horizontally, just readily seen by the naked eye, larger and coarser and more irpiciform when growing vertically or the dissepiments then appearing as linear irregular plates, the dissepiments fluted when oblique. When horizontal, the pore mouths vary in size, often with a few considerably larger than the others. About 4 pore mouths, sometimes 2 or 3, in a length of 1 mm. when growing horizontally. Edges of the pore-mouths irregular, jagged, often plate-like, more or less finely setulose, septa sometimes imperfect. Depth of pores about 0.5 to 0.75 mm. Spores slightly yellowish, oval or pear-shaped flattened on one side, with an oblique apiculus and a central globule, 5 to 7 x 2.5 to 4  $\mu$ ., usually about 5.6 to 6 x 3.5  $\mu$ . Hyphæ faintly tinted, rather irregular, sometimes ribbon-like, thick-walled, occasionally septate, 2.5 to 4  $\mu$ ., occasionally 4.5  $\mu$ .

N.S.W.—On trunk, Hill Top, October (identified by Miss Wakefield, No. 8); Neutral Bay, Sydney, on dead tree, March (identified by Miss Wakefield, No. 13), on dying trunk, August and September; Hawkesbury River, June; near Wangan, Pillaga Scrub, October; near Dubbo, August; locality not stated, turns yellowish-fawn when bruised; locality not stated.

V.—Ararat (E. J. Semmens, No. 10); on the ground, Craigie, June (E. J. Semmens, No. 17).

S.A.—Kuitpo, May; National Park and Belair, April, May (turns yellow with spirit), June (identified by Miss Wakefield, Nos. 1 and 4), on dead branch of *Exocarpus cupressiformis*, Labill., June (identified by Miss Wakefield, No. 2), July, and August; Mt. Lofty, June, July, September; on pine cone, Glen Osmond, July; on fence, Fullarton, July

(colour Light Buff, XV.); Botanic Gardens, Adelaide, on rough *Eucalyptus* bark on living tree, May; Stirling West, July; Mylor, June; Mt. Compass, May (creamy white when fresh); Blackfellow's Creek, February; Encounter Bay, January, May (under-side of fallen *Eucalyptus* bark); Mt. Gambier, May; Quorn, August (edge whitish). One S.A. collection (1926, no locality) has much sterile surface on which in places shallow pores have developed with thick rounded dissepiments and here and there are widely spaced shallow reticulations.

W. Australia.—Pemberton, August.

Tasmania.—Cascades near Hobart, May, August, September; Waterworks, Hobart, July; Port Arthur, January (some of these are *Poria*-like).

N. Zealand.—Wairoa near Rotorua, February.

The *Poria* form presents the same general appearance, though the colour may tend to be deeper. The tints specially noted have been Cinnamon Buff, Warm Buff (XV.), and Ochraceous Buff. The sterile edge may be narrow or in growing parts extensive. Pore mouths as small as 0.15 mm. have been seen and spores measuring  $4.8 \times 2$  to  $3 \mu$ . The localities of the more *Poria*-like plants are as follows:—Q.—Bunya Mts., October. N.S.W.—Moss Vale, November; locality not stated. V.—Staughton Vale, Brisbane Ra., November. S.A.—Kuitpo, March; Mt. Lofty, May; Beaumont, Adelaide, December; Inman Valley, January.

*Form of I. obliquus resembling Poria sinuosa.*—The following agrees almost exactly with specimens identified as *Poria sinuosa*, Weir, No. 10,784, on *Larix occidentalis*, Montana, but does not agree with Rea's description of *Trametes sinuosa*. Ochraceous Tawny (XV.), becoming Ochraceous Buff (XV.) at the edge. Pore mouths 0.25 to 0.5 mm. in diameter, about 3 in 1 mm., edges lacerated, very irregular, mouths finely setulose, substance up to 1.3 mm. deep, subiculum thin, periphery of felted fibres slightly coloured. We refer this plant to *I. obliquus*.

*Form of I. obliquus resembling Poria corticola.*—Dr. G. H. Cunningham has lent us American (?) specimens ( $\frac{157}{2/1/5/2}$ ) identified for him as *Poria corticola*, Fr. Three collections of our series we referred to this species on this determination. They, as well as Dr. Cunningham's specimens, present *Poria*-like but also in places ipiricoid appearances.

On comparing them with specimens identified for us as *I. obliquus* by Miss Wakefield, we are unable to find any means of distinguishing them therefrom, and hence conclude that they are really forms of *I. obliquus*, as is probably Dr. Cunningham's species also. We do not mean to infer, of course, from this that *Poria corticola*, Fr., is synonymous with *I. obliquus*—of this we have no means of judging and the descriptions given by Rea in his *British Basidiomycetes* do not agree. Our specimens to which we refer are the following:—Mosman, Sydney, June, Pinkish Buff to Cinnamon Buff (XXIX.); Cremorne, Sydney, June, Cream Buff to Cinnamon Buff (XXIX.), returned by Miss Wakefield as "indeterminable"; and Neutral Bay, Sydney, December, near Light Pinkish Cinnamon (XXIX.)—all from a locality from which Miss Wakefield has identified *I. obliquus* for us.

*Aberrant and weathered forms of I. obliquus.*—An ipricoid form, paler than Pinkish Buff (XXIX.), which Miss Wakefield (No. 6) considered indeterminable, is, we think, a form of *I. obliquus*. It was responsible for rotting on a fence near Gympie, Q., in August, 1920.

We consider as weathered forms of *I. obliquus* three ipricoid Porias which have assumed a dirty greyish or greyish-brown colour and are obviously old. One was on soft worked wood at Fullarton, S.A., the second on an old board at Millbrook, S.A., and the third on a rotting verandah board, Neutral Bay, Sydney.

*Deeper-coloured form of I. obliquus.*—A plant collected near Ashbourne, S.A., in August, 1924, is deeper than Ochraceous Buff (XV.), up to 1 mm. thick, with the pore orifices irregular, jagged, slightly pilose, 0.15 to 0.25 mm. wide and about 4 in 1 mm., with the dissepiments thin and practically no subiculum.

*Forma labyrinthiformis.*—The following we consider as a growth form. In parts of the same collection, the more normal appearance may be presented. Growing on a rough surface, forming knobby elevations on the subiculum, the tubes more or less fluted or labyrinthiform, often with the dissepiments in places imperfect. A labyrinthiform arrangement may be present without nodular elevations. N.S.W.—Malanganee, 25 miles W. of Casino, August, 1917, returned by Miss Wakefield (No. 9) as indeterminable, between Cinnamon Buff and Clay Colour (XXIX), pores tending to be labyrinthiform, orifices 0.15 to 0.2 mm. wide, edges setulose,

dissepiments thin; Milson Island, Hawkesbury River, August, 1912, not knobby but pores more or less labyrinthiform, near Light Ochraceous Buff (XV.), pores sinuous, septa often imperfect, orifices 0.2 to 0.5 mm. or more wide, about 3 in 1 mm., dissepiments fairly thin with the edges finely shaggy. V.—Staughton Vale, Brisbane Ra., November, showing little coral-like nodules in places. S.A.—On rotting dressed log, Glen Osmond, July.

*I. obliquus* var. *argillaceo-cinnamoneus*, var. nov.—A variety with the pores becoming Clay Colour (XXIX.) or deeper and a pale edge, the general appearance rather coarse. N.S.W.—Yanco, November, 1919, returned by Miss Wakefield (No. 5) as indeterminable, near Clay Colour or darker, the edge pallid and nearly white, felted and almost separable, pore orifices 0.2 to 0.4 mm., about 4 in 1 mm., dissepiments thin with rather jagged edges. S.A.—Mt. Lofty, June, 1917, Clay Colour, deeper than Cinnamon Buff, irpiciform, pore orifices about 0.4 mm.

What we in Australia understand as *Irpex obliquus* is a variable species. One form grades into another, but the extremes may differ so from each other that anyone, not having an ample series of "between" forms, may readily consider he is dealing with several distinct species. No one can say whether or not these forms breed true, and so are incipient varieties. As the irpiciform, poria-like, and labyrinthiform appearances may occur in the same plant, this aspect of the shape of the pores is evidently chiefly one of position and not varietal. It may be well for us to state in broad terms as a guide to other collectors what types of plants we would place under *Irpex obliquus*. Resupinate irpiciform, or poria-like fungi, indeterminate and often extensive, in colour near Pinkish Buff, Cinnamon Buff, or Light Ochraceous Buff, with a felted sterile edge sometimes extensive of the same colour or slightly paler but not pure white, thin (up to 1 mm.), adherent, the tubes somewhat variable in size but mostly 0.2 to 0.4 mm. in diameter, 2 to 4 in 1 mm., irpiciform or definitely poria-like but if the latter with thin dissepiments tending to be lacerated and the mouths more or less setulose, spores 5.2 to 7 x 2.5 to 3.8  $\mu$ ., usually 5.5 to 6 x 3.5  $\mu$ .

37. *Poria selecta*, Karst.—We have had considerable difficulty in placing a not uncommon usually thin cinnamon buff or pinkish buff *Poria* which resembles in general *Irpex obliquus*, but has smaller and more regular pores and nar-



rower, slightly curved spores ( $5.5 \times 2 \mu$ ). There seems to be considerable variation in our specimens, probably dependent for the most part on the age and on the substratum. This variability has led to our being able to match individual plants reasonably well with several exotic species which have been identified and forwarded to us by authorities in other parts of the world. Thus Dr. J. R. Weir's No. 15,904 from *Pinus contorta*, Idaho, labelled *Poria selecta*, Karst. (= *P. vulgaris* var. *flava*, Fr.), corresponds almost exactly with plants from Bradley's Head, Sydney, April, 1919. Specimens also resemble closely *Poria vulgaris*, Fr., kindly forwarded by Miss E. M. Wakefield, though in most cases the colour is more vivid, and this supports the identification of *P. selecta* which Dr. Weir indicates has been considered as a variety of *P. vulgaris*. Other specimens from near Ashbourne, S.A., August, 1924, resembled so closely Dr. Weir's No. 11,666, *Poria cinerescens*, Bres., growing on *Pinus monticola* in Idaho that we at first placed it under this species. His specimen has, however, a pure white edge and ours one which is nearly but not quite pure white. Moreover, Bourdot et Galzin in their "Hyménomycètes de France" (Bull. Trem. de la Soc. Mycol. de France, XLII., 1925, p. 227), refer to this species as "très robuste, très "lignivore, à la manière de *P. medulla-panis*," which hardly fits our plants or, as a matter of fact, Dr. Weir's. Other specimens have shown a resemblance to American plants identified as *Poria corticola*, Fr., but Rea's description of the species in his *British Basidiomycetes* seems to rule this out. We have therefore decided to refer our plants to *P. selecta*, Karst., considering the variations as being due to habitat, etc., and not of specific significance and in any case being so intangible and so grading into each other as to defy description and differentiation in words. It may be that we have thus grouped together more than one true species and that in the future some clear-cut means of distinguishing these may be found. Moreover, considering the habitat, frequently on *Eucalyptus* bark or wood, it is quite likely that we have to do with a purely Australian species. For the present, we place our plants under *P. selecta* and describe separately several different collections so as to indicate the variation. Some specimens seem to grade into *Irpex obliquus* and it may be hard to decide to which they belong.

Forming irregular patches,  $10 \times 2$  cm. in size, near Pinkish Buff (XXIX.) or greyer, semi-detachable, with a broad irregular indeterminate felted-fluffy nearly whitish

margin, very thin, rarely nearly 1 mm. thick, pores about 0.25 mm. deep, orifices variable, somewhat angular, 0.1 to 0.32 mm. wide, 3 to 5 in 1 mm., dissepiments thin, smooth. Spores  $5.5 \times 2 \mu$ . Hyphæ septate, irregular, sometimes varicose, branching at right angles, 2.5 to 4, rarely 7,  $\mu$ . wide. Near Ashbourne, S.A., August, 1924. Specimens from Mt. Lofty, S.A., July, 1927, were readily trituated, orifices 3 to 4 in 1 mm., dissepiments rather thick, setulose, shed spores slightly curved, narrow, hyaline,  $5.6 \times 2 \mu$ , hyphæ 3 to 5  $\mu$ .

A *Poria* growing as small rounded discoid patches on twigs, Milson Island, Hawkesbury River, N.S.W., July, 1912, returned by Miss Wakefield (No. 17) as indeterminate, appears to be this species.

Forming widely effused indeterminate patches, 8 x 4 cm. or more, in colour Cinnamon Buff (XXIX.) or paler, the sterile narrow irregular margin paler and membranous—arachnoid, membranaceous (0.25 mm. thick) to 2.5 mm. (Neutral Bay specimens), adherent, pores from very shallow to 2 or 2.5 mm. long, pore orifices 0.1 to 0.15 mm. wide, often sinuous, the dissepiments thin and often defective, the edges finely setulose, sometimes irpicoid, subiculum very scanty, covering rotten wood near the ground and sometimes extending to the soil and felting small sticks and soil together by a pore-bearing irregular surface. N.S.W.—Bradley's Head, Sydney, April, 1919, and Neutral Bay, Sydney, February, 1913.

Specimens from the National Park, Tasmania, January, 1927, form thin ill-defined extensive patches many inches long and several wide, pore orifices 4 to 5, sometimes 6, in 1 mm., dissepiments thin, fibrillose, hyphæ irregular, often thick-walled, 2.5 to 4  $\mu$ . We have specimens also from The Cascades near Hobart, May, 1924.

38. *Poria minutipora*, n. sp.—Forming extensive patches up to 10 x 5 cm. or more, more dingy and in places darker than Pinkish Buff (XXIX.) with a sheen, rather silky-soft to the touch, 1 mm. thick, consisting chiefly of the pores with a thin layer of white byssoid subiculum, indeterminate, with in parts a narrow or more extensive sterile byssoid or quite smooth white edge. Pores 0.7 mm. deep, orifices 0.1 mm. diameter, 7 in 1 mm., dissepiments thin, rounded, edges tending to be setose or jagged. Hyphæ 2 to 3  $\mu$ . thick, rather irregular, white. N.S.W.—Malanganee, 25 miles west of Casino, August, 1917.

We refer to this species three Tasmanian collections with very minute pores, 5 to 6 in 1 mm., the dissepiments rather rounded or thin and jagged, in colour whitish with a delicate buffy tint, up to 1.5 mm. thick and forming discoid or elongated patches several inches long and with edges fairly sharply defined or thin and encrusting with ill-defined edges. The whitish edge and penetrating mycelium are fluffy. Hyphæ rather irregular, 2 to 2.5  $\mu$ . National Park, January; Cascades near Hobart, October.

39. *Poria carneo-lutea*, n. sp.—Irregularly effused forming a thin crust-like layer, not readily separable, Pinkish Buff (XXIX.), the growing edge narrow, of the same colour or a little paler and finely pilose, up to 1 mm. thick, corky to subfriable, tending to crack, pores 0.5 mm. deep, orifices 0.1 to 0.32 mm. wide, usually under 0.24 mm., 4 to 5 in 1 mm., the edges pilose and not ragged, dissepiments rounded and 0.05 to 0.1 mm. thick, substratum almost negligible, spores not seen, hyphæ faintly tinted yellowish, rather irregular, 2 to 3.7  $\mu$ . N.S.W.—Bullahdelah, August, 1919—returned by Miss Wakefield, No. 10, as indeterminable.

40. *Poria hyalina*, Berk.—Miss Wakefield (No. 18) has identified the following specimen for us. It forms a somewhat circumscribed thin patch with an indefinite edge, between Clay Colour and Tawny Olive (XXIX.), in places darker than the latter, composed of the very small obliquely set pores presenting a somewhat translucent appearance (like dried gristle) resting on a very thin whitish subiculum. The surface tends to split. The thickness is about 1 mm. The orifices are closely set, about 6 in 1 mm., with thin dissepiments. Hyphæ nearly colourless, 2 to (usually) 3.7, occasionally 4.2  $\mu$ , calibre a little irregular. N.S.W.—Orange, October, 1914.

We also identify as this species a Tasmanian *Poria* (No. 1, specimen 2)—the type came from Tasmania. In this the plant is thicker (2.5 mm.), the colour is near Clay Colour (XXIX.) towards the surface and only the terminal parts of the tubes present a somewhat hyaline appearance, the basal parts like the thin subiculum being white. The pores are approximately of the same size but set vertically. The surface also splits. Hyphæ faintly yellowish, rather thick, 3.7 to 4.6  $\mu$ , a little irregular. Specimens from The Cascades near Hobart, November, 1919, form a very thin layer (about 1 mm.), show many small cracks and the older pores are of the Clay Colour and sub-hyaline appearance, but

the younger ones are paler gradually fading to nearly white. Hyphæ a little irregular, 2 to (usually) 2.5  $\mu$ . in diameter. Amongst other specimens collected at The Cascades in September, 1920, and May, 1924, are examples showing a nearly white opaque pore surface with patches showing a semi-translucent appearance or a whitish periphery with the clay colour appearing in the older parts.

A South Australian specimen collected on the Sturt River, Coromandel Valley, June, 1927, seems identical with one of the Cascades specimens. We believe that three further South Australian collections should also be placed here, agreeing in the minuteness of the pore orifices and a sub-hyaline appearance of the pore surface but presenting a deeper colour (ochraceous buff, cinnamon buff). These may be mature plants but fresher and less weathered. Kuitpo, May, 1921—forming small patches about 2.5 x 1.5 cm. in size, with pallid felted edges contrasting with the pore-bearing surface which is between Ochraceous Buff and Ochraceous Orange (XV.), later approaching Ochraceous Tawny (XV.). Tubes about 1 mm. deep, forming most of the thickness, orifices about 0.1 mm. wide, about 9 in 1 mm., honey-comb-like and rather polygonal, sometimes fluted, dissepiments very thin. Mt. MacIntyre near Kalangadoo, S.E., Dec., 1922.

Forming extensive thin patches up to 10 x 4 cm., tending to split, near Cinnamon Buff (XXIX.) or paler, subdeterminate, with a narrow sterile felted white edge, thin, usually about 0.75 mm., rarely in places 3 mm. thick, the white subiculum contrasting with the cinnamon buff pores, tubes 0.75 to 2 mm. long, orifices 0.15 to 0.24 mm., about 6 in 1 mm., edges smooth, dissepiments thin or rounded. Spores (?) spherical, 4.5 to 5.5  $\mu$ . Hyphæ a little irregular, thick-walled, apparently sometimes septate, 2 to 3.5  $\mu$ . Dr. Weir says of this specimen that it "may be referred to *Poria vaporaria*, "Fr., form. The spores are, however, not very allantoid. "The species has no doubt a name, but I have not yet "located a type. It may be *Poria tarda* (Berk.) from W. "Australia." A specimen identified by Dr. Weir as *P. tarda* for Dr. Cunningham in New Zealand is however quite unlike our plant, and we think the latter is best placed under *P. hyalina*. The third collection is from Mt. Lofty, June, 1928.

41. *Poria calcea*, Berk. and Br. (non *P. calcea* (Fr.), Bres.).—Through the courtesy of Mr. Cyril White, Govern-

ment Botanist of Queensland, we have portion of the specimen collected by the late F. M. Bailey (No. 119) and recorded in Cooke's Handbook of Australian Fungi (No. 817) for Queensland. This was collected at Trinity Bay. A specimen of ours from Lismore, N.S.W., October, 1912, exactly matches it. The species forms extensive hard but brittle patches, up to 20 x 8 cm. in size, Light Buff (XV.) or a little darker in colour, rather than "chalky white," under 0.5 to 1 mm. thick, densely adherent to the substratum. The pores are very minute, usually about 6 in 1 mm., 0.174 to 0.260 mm. in diameter, and very shallow, the orifices rather polygonal and the dissepiments very thin. When developed, the pores may form about half of the total thickness, but even in large patches are often not much more than raised reticulations, with the dissepiments occasionally defective. On dead decaying wood, sometimes penetrating through thin superficial layers, and appearing below, where separation occurs, as a tenuous pallid indeterminate film on which the minute pores soon appear. Hyphæ white, in short lengths, slender, 1.5 to 2.5  $\mu$ . We have not seen the spores in our specimens.

This species approaches in general appearance thin specimens of *P. medulla-panis*. The abundant characteristic spores of the latter are, however, absent.

42. *Poria purpurea*, Fr.—Bourdot et Galzin (Bull. Trem. de la Soc. Mycol. de France, XLI., 1925, p. 220) place *Poria purpurea* in Sect. *Meruliezæ*, in which the pores are meruloid and later more definitely tubular with entire orifices. In their description of the species they describe it as "rounded, oblong, then confluent, tender, thin, more or less adherent, at first white (or yellowish sub-ochraceous), soon purplish or rosy, then purplish red or blackish purple; pores reticulated alveolar, then rounded angular . . .; edge usually straight, pubescent or pruinose, white or clear rosy; . . . spores 6 to 9 x 2 to 2.5  $\mu$ ." From this description, there seems no doubt that the following Australian plants belong to this species, though the spores are definitely smaller (4.2 to 5.5 x 2  $\mu$ ).

Forming small to extensive thin adherent ill-defined patches sometimes 8 ins. (20 cm.) or more long, with the pores at first meruloid, and in which vinaceous purple tints are present in places, though sometimes the predominant colour may be a pale buff passing into a tawny olive. Spreading edge indefinite, filmy, byssoid to villous, Light Buff

(XV.), Pale Pinkish Buff (XXIX.) to Cream Buff (XXX.), sometimes with vinaceous tints which may also appear in the substratum. As the substance increases in thickness, eventually reaching 1 mm.; pores develop, first as shallow reticulations (often purplish), producing alveoli varying in size, averaging about 3 in 1 mm., sometimes 5 in 1 mm., the pore surface thus produced pale buff in colour, but in parts Dark Purple Drab and Vinaceous Drab (XLV.) or Perilla Purple (XXXVII.). As the pores develop they increase in depth to reach in places nearly 1 mm., forming most of the substance; the orifices vary in size, about 3 in 1 mm., some 0.5 mm. in diameter, others 0.25 mm. or even 0.16 mm., the dissepiments thin or in places thicker and rounded or sometimes the pores may appear like pinholes widely separated from each other. Eventually the thicker parts of the pore layer may assume a Tawny Olive (XXIX.) tint. Hyphæ whitish, septate, thick-walled, irregular, branching at right angles, 3.5 to 5  $\mu$ . Shed pores slightly curved, narrow, rod-shaped, cream-coloured to white, 4.2 to 5.5  $\times$  2  $\mu$ . S.A.—Humbug Scrub, April, 1926; National Park, May, 1925 (the Vinaceous Drab pore area forms a considerable patch). N.S.W.—On dead stump, Neutral Bay, Sydney, May, 1913.

43. *Poria vineta*, Berk.—This species is placed by Cooke (Handb. of Aust. Fungi, No. 822) under the heading "Pores flesh-coloured," and is described as "wholly resupinate, "rather thick in the centre; margin thin, somewhat free, "tinged above with red (4 mm. thick in the centre); pores "small, pallid, substance wood colour."

One of us submitted a Tasmanian *Poria* to the late Dr. C. G. Lloyd as probably *P. vineta*. Dr. Lloyd in replying said that "*Poria vineta* was an Eastern species named by "Berkeley that came into use in American tradition, but this "is not the plant that has been called in the United States "*Poria vineta* of Berkeley." Dr. G. H. Cunningham has lent us a specimen, No. 20,059, identified by Dr. J. R. Weir as "*Poria vineta*, Berk. (= *P. attenuata*, Peck) on *Pinus "virginiana*." The Australian species is close to this but not, we think, identical—though the colour is nearly the same, the pores in our plants are much smaller.

We have a series of Australian plants which, though very variable, seem all to link on with each other, extremes being sometimes met with in the same collection, and in which the whole plant or some part shows a colour which may be called a vinaceous-flesh (vinaceous fawn, pinkish

cinnamon), the colour extending into the substance, the pores minute. The plants may be very thin and nearly membranous, or become thick from 1 to even 6 mm. in depth. Though the plants usually have the above vinaceous or fleshy tint this may not be appreciable in thin specimens in which the colour may be cinnamon or brown. We describe separately thick specimens from N.S.W. and Queensland, and thin specimens rarely up to 1 mm. thick from Tasmania.

Forming extensive patches 10 cm. or more long and up to 4 cm. wide, in colour near Vinaceous Fawn and Avellaneous (XL.) becoming browner, varying in thickness from 1 to 6 mm., the edges irregular but sharply defined with a very narrow paler sterile edge. Substance corky to woody, near Avellaneous. Pore mouths very minute, about 6 in 1 mm., dissepiments rounded. Spores (apparently) subspherical, 2.5 to 5  $\mu$ . Hyphae whitish, about 3  $\mu$ . thick, with much granular material. N.S.W.—Malangane near Casino, August, 1917; Comboyne, August, 1918. Queensland.—Bunya Mts., October, 1919.

Forming thin patches up to 7 x 4 cm., Pinkish Cinnamon, Cinnamon and Clay Colour (XXIX.), or between Light Pinkish Cinnamon and Pinkish Cinnamon but darker, or near Light Ochraceous Buff (XV.), or Light Vinaceous Cinnamon, or paler than to deeper than Light Pinkish Cinnamon becoming when old near Cinnamon (XXIX.) to Cinnamon Rufous (XIV.) or browner than Cinnamon near Sayal Brown (XXIX.), rather indeterminate, with the sterile edge paler and sub-byssoid, occasionally with a reflexed villose border above, forming a narrow pileate shelf, membranous, very thin (usually under 0.5 mm., rarely nearly 1 mm. thick), pore orifices minute 0.08 to 0.13 mm.,  $6\frac{1}{2}$  to 11 in 1 mm., finely setulose, dissepiments thin.

Tasmania.—Many specimens, including Cascades (January, 1920; May, 1926; August, 1918), Waterworks Gully (July, 1920), Brown's River (January, 1928). S.A.—On dead wood, Mt. Lofty, June, 1917.

44. *Poria attenuata*, Peck.—The following agrees with American specimens on *Picca Engelmanni*, in Montana, kindly forwarded by Dr. James R. Weir. Forming irregular patches up to 7 x 3 cm. in the hollows and interstices of a rotting *Pinus* log. The sterile mycelium is extensive, villose, and pallid ochraceous, as the pores develop, first as minute pits, becoming Ochraceous Salmon (XV.), passing

as the tubes elongate to near Argus Brown (III.) and when old becoming darker near Burnt Umber (XXVIII.). The fungus is firmly adherent to the substratum. The brown pores eventually form a layer up to 2 mm. thick, resting on the light pale decaying wood without any obvious substratum. The orifices are exceedingly minute, about 6 in 1 mm., slightly variable in size, the dissepiments rounded. Hyphæ whitish, irregular, branching irregularly, with transverse connections and much debris, 2 to 4.8  $\mu$ . Beaumont, Adelaide, June, 1917.

45. *Polyporus adiposus*, B. and Br.—Rea, in his *British Basidiomycetes* describes this species as being white, here and there acquiring a foxy tinge, often entirely resupinate, and with the tubes whitish, tinged in places with brown, short or long, their orifices small and round or angular and torn, the spores white, globose, 4 to 5  $\mu$ ., the whole fungus turning brown in drying. It is found on ditch sides, the ground beside stumps, and mosses. As a synonym, he gives *P. undatus*, Pers. sec. Bres. and refers under this name to Lloyd, Synop. Sec. Apus Gen. Polyp. figs. 662 and 663.

Lloyd describes *P. undatus* as white, usually resupinate, rarely developing a pileus, turning dark reddish brown in drying, the pores minute or hiascent, in an oblique position, the mouths cinereous when dried, spores globose, 3 to 4  $\mu$ . He says that in the United States it always occurs as a *Poria*, is frequent and forms slabs on very rotten logs. It has been distributed as *Polyporus Broomei* by Rabenhorst and by Sydow, and Bresadola referred *P. adiposus* to it.

Miss Wakefield has sent us a specimen of *P. adiposus* from soil on the side of a drain, Doncaster, England. We have a specimen collected at Mosman, Sydney, in June, 1919, which we refer to this species. It forms a layer about 2 mm. thick, covering the irregularities of caked soil near wood and in colour is near Sayal Brown (XXIX.) which is perhaps somewhat "foxy" in tint. The tubes are mostly oblique, but in places horizontal, when the orifices are fairly regular, about 5 in 1 mm., the dissepiments rather thin. The colour is a little deeper than in Miss Wakefield's specimen, and the mouths of the pores are not cinereous, as they are to some extent in the English specimen. There are abundant, white, irregularly spherical (collapsed ?) spores, 3 to 4  $\mu$ . in size, and the hyphæ are fine, irregular, nearly colourless, about 1.5  $\mu$ . in diameter.



We have seen a New Zealand specimen, identified for Dr. G. H. Cunningham by the late Dr. C. G. Lloyd, on dead bark at Weraroa, which at first sight is quite unlike Miss Wakefield's plant. The pores are oblique, and the specimen resembles some Australian plants which link on with the English one. Evidently the species is very variable. A specimen sent to Dr. Cunningham by Dr. James Weir and identified as *Poria undata*, Pers. (*Polyporus zonalis*, var. *resupinata*), on dead wood of *Quercus rubra*, Washington, No. 20,051, seems a different species, as the synonym suggests.

We would refer also to *P. adiposus*, a plant from a wood heap in Sydney, August, 1918, forming scattered irregular thin patches, up to 5 x 2 cm. in size, the tubes very oblique and near Pinkish Buff (XXIX.) on a paler sterile portion, hyphæ 2.7 to 5  $\mu$ ., slightly yellow and rather irregular, showing occasional knobs. A specimen from Dorrigo, N.S.W., January, 1918, is probably also *P. adiposus*. It forms an encrusting and penetrating growth, 12 x 2.5 cm. in extent on very rotten wood on the forest floor, in colour greyer and darker than Pinkish Buff (XXIX.). Another N.S.W. specimen (no locality) forms an extensive encrusting mass on rotting wood, has rather cinereous mouths to the pores, and hyphæ white or slightly coloured, rather irregular, with branches at right angles, 3.5 to 5.5  $\mu$ . thick.

## ROBERT BROWN AT PORT DALRYMPLE.

By

R. W. GIBLIN, F.R.G.S., F.R.E.S.

(Read 10th June, 1929.)

Robert Brown was a passenger on board the *Lady Nelson* when that vessel was sent by Governor King in December, 1803, to assist Lieut.-Governor Collins transport his party either to Port Dalrymple or the Derwent River, as he might select. Detained at Kent's Group through bad weather her destination was changed when William Collins, who had been sent off from Port Phillip in the *Francis* to make an examination of Port Dalrymple, arrived at Kent's Group with the *Francis* in a crippled condition, sent that vessel on to Sydney for repairs, and going on board the *Lady Nelson* proceeded to Port Dalrymple to carry out his instructions. Brown when on the *Lady Nelson* was a passenger with a mission—botanical research work—and his voyage in the colonial brig enabled him to engage in field work at the Kent's Group, at Port Dalrymple, and at Port Phillip, before he passed on, still in the *Lady Nelson*, to the Derwent River, where he devoted himself to his scientific studies for nearly six months.

William Collins's report to his Chief on the country about Port Dalrymple was fairly favourable. Brown was little impressed with it, and the following "Field Notes" probably furnish the reasons for his low estimate of its character. Their chief value to-day lies, perhaps, in the references to encounters with the local natives. His botanical jottings, which are not extensive, not being easily decipherable by a layman, are omitted.

January 1<sup>st</sup>, 1804.

In the *Lady Nelson* Brig belonging to Port Jackson anchored abreast of Lagoon beach about a quarter of a mile from the shore & nearly the same distance within the shoals of the entrance of the Port.

I landed in the forenoon & walked a little way inland to the first rising ground.

The Country in the neighbourhood of Lagoon beach was on fire.

On a rising ground about  $\frac{1}{2}$  mile from the beach I observd eight native huts which appeard to have been long deserted: in every respect they resembled those describd by Mr. Bass each of them were capable of containing two people only.

The Soil behind the beach & as far as the extent of my walk was very sandy & poor even in the hollows.

The Lagoon mentiond in Capt. Flinders' Memoir was at this time nearly dry it is of considerable extent. In its neighbourhood there were some ponds not quite dryed up the water of which tho stagnant & warm was not ill tasted nor brackish.

A few black Swans were seen flying up the Port Several Kanguroos most of them large Pattermelons a few forest Kanguroos.

Messrs. Humphrey, Collins &c who had walkd along the beach towards Outer Cove were met by a party of natives who seemd disposd to be troublesome & unfriendly & obligd them to return abreast of the Ship.

The Stone formd on the side of the Lagoon beach consisted of Granitell composd of and resembling Basalt or Hornslate on the opposite side of the beach Ironstone was observd.

January 2<sup>nd</sup> In the forenoon I landed abreast of the vessel & walkd to Low-head and returning to Lagoon beach walkd towards Outer Cove & returnd to the Ship a little after sunset.

The rocks on the shore are like those abreast of the anchorage with here & there fragments of ironstone Low head consists of the same Granitell as that at Lagoon beach It contains no veins or crystals it is rudely rent into fragments of various sizes & forms Soil near the beach extremely poor & sandy.

Jany 3<sup>d</sup>.

At 7 AM got under weigh & ran up & anchor'd in Outer Cove completely landlockd.

Natives about 20 came down to the beach but on our pulling towards them in the boat they went back into the woods and we saw no more of them to-day Landed about 12 & returnd on board about half past 2 PM Walkd a little way into the country soil rather light & sandy & probably

not deep, free in general from stones & pretty uniformly covered with grass not remarkably luxuriant but not growing in tussocks.

In the afternoon visited & walkd over Green Island small flat & stony but thickly covered with pretty tall grass mixed with several herbaceous plants & here & there patches of small trees.

January 4th. At 7 o'clock AM I landed & walkd to the nearest hills on the eastern shore bearing from the ship E S E & not more than a mile & half or two miles from the shore.

From the Cove to the base of these hills the country is level & consists mostly of forest land with here & there thickets of no great extent. The soil is very poor and sandy, often mere sand. About half way we crossd a swamp at present nearly dry & not very extensive. The Eucalyptus resembling the Boxtree of Port Jackson is frequent & of considerable size. The Hills are very stony & barren composed of Granitell similar to that observd on the shore, or an aggregate of quartz mica & oxyd of Iron.

A party of Natives appeard to have been watching us & followd us to the bottom of the hill where we had a friendly interview with four of them. We gave them biscuit which they did not however eat, a few trifles & shewd them the use of a hatchet wch we could not well spare them. They admird the effects of the hatchet & our skins wch we shewd them. One of them gave me a young Pigeon wch appeard to have been speard in return for a piece of biscuit.

In their persons & colour they exactly resemble the inhabitants of N S Wales in stature they do not fall short of them & are rather better made especially in having fuller calves to the legs their hair however is wooly tho I think not so much crispd nor of so full a black as the African negro.

The hair of the head was in most of them covered with ochre by wch in some especially in the lads the wool was divided into small parcels. The faces of some were blackend & in the colouring matter a considerable proportion of minute mica was containd. Their arms & thighs were tatood & in many was an archd line across the abdomen most of them had all their teeth perfect wch were in general white but not uncommonly white. The features of the boys were rather pleasing.

They speak quickly & their tones are not unpleasant I could not get them to understand that I wished to have their names for the different parts of the body.

On the top of the hill we sat down & in a few minutes 12 natives joined us at first they conducted themselves in a peaceable manner but by & bye they began to shew some symptoms of distrust as on my making some attempts to acquire a little of their language one of them snatched up a piece of wood & threatend to throw it at me at the same time raising his spear & two of them shapd their spears to throw at me I was then scarce five yards from them the rest of the party being a few paces behind me.

I went cautiously back keeping my face to them they didn't throw any spears but came close up to us We then found it necessary to fire a piece in the air at the report of wch they took to their heels but did not run far & continued while we leisurely walked down the hill on our return to the ship to follow us at scarce more than 30 yards distance.

As they seemd again inclin'd to close with us a piece charged with buck shot was fired at one they then took once more to their heels and afterwards followed at a greater distance We reachd the beach without further molestation It did not appear that the man fired at was hurt.

Janv 5. Forenoon landed & walkd a little way up the creek wch at no great distance from the beach contains fresh water especially in its smaller bifurcation Fresh water may also be procured by digging about 80 yards from the mouth of the creek on the right hand side going up.

In the afternoon got under weigh and anchored on the west side immediately above the western arm landed in the evening & walkd about half a mile into the country which is quite flat well wooded the trees tall & of considerable girth the largest a new species of Eucalyptus in bark & external appearance resembling the Boxtree of Port Jackson but differing in its wood The oaks of moderate or inferior size ground thickly covered with grass not tufty, soil light sandy depth not ascertaind swampy meadow covered with small grass.

Janv 6th. Early in the morning set off for the hills bearing from the Ship on our way about 4 miles from the landing place crossd a creek which on our return

a little higher up we found to be fresh about 1 o'clock reachd the top of the hill the height by a rude computation might be 1,200 feet it is no way remarkable either in height or figure from those in the neighbourhood it is composd of a [?] stone graduating sometimes into a very fine slate of a light ash colour with exceedingly fine [?] at the base of the hill and on the lower hills we found Pudding stone on the surface the stone composing the hill often contains thin veins of quartz on the surface of the hill observd red micaceous Iron ore fragments of Quartz plentifully strewd over the surface between the shore and the hills. Soil nowhere rich not always fit for pasture at best a poor clay Hills very stony with no depth of soil.

At the base of the hill a run of excellent fresh water weh probably empties itself into Western cove Trees as before Returnd on board in the evening.

Janv 7. In the morning about 7 weighd & stood up the river at noon were abreast of Egg Island where we anchord a party landed a plant observed on the Island not seen anywhere else in the Port, afternoon weighd & stood on past the *Norfolk's* highest anchorage about a mile and not keeping the channel groundd in four feet muddy bottom but the tide flowing got off & anchord in the channel in 7 fathoms landed in the evening at the mouth of a small creek walkd a little way along the banks of the creek soil on the slope of the hill tolerable blackish clayey loam about 10 or 12 inches deep bottom clayey.

Omitted Janv 7. Anchord about  $\frac{1}{2}$  mile below middle Island on the eastern shore Landed in search of fresh water found none the hills marked in the chart being quite dry, soil very poor & stony.

Janv 8th. In the morning went up about 2 miles in the boat in search of fresh water but found none a hole dug in very pure clay a considerable distance from high water mark in a coppice of *Melaleuca* produced water as salt as that of the river. I returnd in the boat to the ship the party went on Afternoon weighd & stood up the river anchord about half a mile above Upper Island not far from where the river becomes much narrower. The channel here very narrow.

Janv 9th. In the morning Messrs. Collins & Symmons left the vessel in the boat intending to proceed up the river

till the water became fresh or till fresh water could be procured, our stock being exhausted to within a very few gallons & that both brackish & putrid. They returned in the evening a little before sunset with a few casks of fresh water. They had proceeded up the river in the boat about  $3\frac{1}{2}$  miles when they found it to divide they followed the larger branch but it narrowed into a mere canal & it was not till then that it became fresh.

On returning they went into the smaller branch which they found to be a river of pure water confined into a narrow channel bounded by perpendicular rocks of considerable height.

Jan<sup>y</sup> 10. At daybreak left the ship purposing to examine the steep banks of the River discovered yesterday. We reached it in about an hour the boat could not get up it farther than about  $\frac{1}{12}$  of a mile the bed of the river was above that filled with large stones & its descent in several places rapid. About 300 yards farther up it dilates into a small still basin & afterwards narrows into a rapid current broken by huge masses of stone in its bed as before. We followed it about half a mile up but its banks were so rocky & our time limited that we were obliged to return to the boat. Got on board about 11 AM got under weigh soon after but very soon got aground where we remained till in the mean time the boat made another trip for fresh water & returned about 8 PM.

Jan<sup>y</sup> 11<sup>th</sup>. In the morning warped the vessel down abreast of Upper Island five native women came down to the shore abreast of the ship but on our putting off in the boat towards them retired into the woods. In the evening anchored about 2 or 3 cables length above our anchorage of the 7<sup>th</sup> went on shore in the evening. The shore covered with Ironstone.

Jan<sup>y</sup> 12. A wooding party went on shore and returned about 11 AM got under weigh before 12. In the evening anchored abreast of Egg Island went on shore for a few minutes.

Jan<sup>y</sup> 13. In the morning landed on the shore abreast of the ship went up with the boat a creek the mouth of which was not visible from the ship nor indeed in any part of the river about 3 or 4 cable lengths from the opening it

terminated in a stream of fresh water running over a very rocky bed, its breadth a few yards the depth not great walked along its banks about 1/10 mile the land on each side rises with a quick slope is forest land but rather stony & of a light soil The stone composing its bed & rocky banks Hornslate.

At high water fresh water may be had with the greatest ease as then a boat can go close up to the fall, at low water a boat cannot get up to the fall.

Jan. 14. In the morning got under weigh & early in the forenoon anchored a little above Middle Island Landed & walked over part of the flat country behind Middle Island The soil is in general pretty good but upon the whole rather loose it would answer well however as pasture ground The hollows are somewhat swampy & are unfit for any kind of pasturage Here & there there are patches of Brush Returned on board about 4 PM After dinner visited Middle Island it is in part stony but contains also some tolerable pasture land.

The shore abreast of the ship as well as of the Island is generally covered with Ironstone in fragments of various sizes a few fragments of Petrosilex & more generally Basalt or Hornslate small quartz pebbles cover some parts of the beach.

Jan. 15. Weighed & in the forenoon anchored between Green Island & Middle Rock.

The natives to the number of 30 or upwards including Women of whom there were several came down to the shore abreast of the ship & as appeared to us by their gestures wished us to land & renew our intercourse The women danced to the song of the men who beat time very exactly with their waddies on their cloaks We were not sufficiently near to discern their movements in the dance On a red flag being displayed from the ship they frequently repeated Lappoo Lilley Lappoo Lilley.

The song was different from that of the Port Jackson natives Hoping to pick up some of their language & more accurately to contemplate their persons & manners a party pushed off from the ship in the boat but before the boat could land the women were sent away & the men came down on the shore shouting & throwing stones at us, two shots were fired over their heads upon which they ran off a little way & upon our landing they retired into the woods & did not return.



On our way back to the ship landed on Middle rock which is covered with muscles at low water oysters may be found on it. In the evening the ship was warped into the cove within Outer cove.

Jan'y 16. Dropd down to Lagoon Beach where we remained till the morning of the 19<sup>th</sup> in which time the entrance was more particularly examined by Mr. Collins who landed also on the opposite side.

Jan'y 19<sup>th</sup>. Sailed for Port Phillip where we arrived.

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The *Lady Nelson* arrived at Port Phillip on the 21st January, 1804. The encounters with the natives described by Brown in his rough field-notes were in all probability the first in which whites and blacks were brought into intimate contact at Port Dalrymple. Flinders and Bass in 1798 caught sight of a few of the savages, but did not come to close quarters. We do not know if Louis Freycinet when he visited the port early in 1802 even saw any of them. Writing to Colonel Collins on the 30th December, 1803, Governor King informed him that a schooner had just returned to Sydney from Port Dalrymple "after an unsuccessful attempt to procure Fresh Water in search of which he" (the Captain) may have been impeded by the natives, who "were extremely inimical to him." This schooner was the *Governor King*, a sealing vessel belonging to a Sydney firm. The ways of sealing-men with natives later became a by-word and a scandal, but it does not follow that the crew of the *Governor King* were the aggressive party on that occasion. Indeed, it would appear from the fact that Brown and his companions were able to get into touch at all, though only for a short time, that the aborigines of the district, probably the same as those met with by the sealers, were not harbouring vindictive feelings towards whites generally on account of previous wrongs.

Brown's sketches of the natives, slight as they are, properly belong to the category of those fuller pictures which we owe to earlier visitors, and which deal with the period before they were brought into downright opposition with the invaders of their territory when the permanent British settlement of the island took place in 1803 and 1804.

# ADDITIONS TO THE CATALOGUE OF TASMANIAN MOLLUSCA.

By

DR. P. ANSELL ROBIN.

(Communicated by Clive Lord.)

(Read 10th June, 1929.)

*Ancilla edithæ*, Prit. & Gat.

1899 *Ancilla edithæ*, Prit. & Gat. P.R.S. Vic., vol. XI.  
n.s., p. 181, pl. XX., f. 5.

Habitat—Circular Head. Not uncommon (dead).

*Philine trapezia*, Hedley.

1902 *Philine trapezia*, Hedley. P.L.S. N.S.W., XXVI,  
p. 704, pl. 34, f. 22-24.

Habitat—Circular Head. One dead specimen.

*Solemya australis*, Lamarek.

1904 *Solemya australis*, Prit. & Gat. P.R.S. Vic.,  
XVII., n.s., 1904, p. 220 (q.v. for bibliography).

Habitat—Circular Head. One valve.

*Condylocardia chapmani*, Gat. and Gab.

1912 *Condylocardia chapmani*, Gat. & Gab. P.R.S.  
Vic., XXV., n.s., pt. I., p. 167, pl. IX., f. 5-8.

Habitat—Circular Head. Four dead specimens.

*Diala varia*, A. Adams. Ann. Mag. Nat. Hist. (3) viii., 1861,  
p. 243. Hedley, P.L.S. N.S.W., 1913, XXXVIII.,  
pt. 2, pl. xviii., f. 56.

Habitat—Circular Head. Not uncommon (dead).

*Cylindrobulla fischeri*, Ad. and Ang. P.Z.S., Lond., 1864, p.  
37. Hedley, P.L.S. N.S.W., 1903, XXVII., p.  
604, pl. xxix., f. 8, 9.

Habitat—Circular Head. Two dead specimens.

*Heterorissosa wilfredi*, Gat. and Gab. P.R.S.V., XXIV., n.s.,  
pt. 1, 1911, pl. xlv., f. 3. Iredale, Proc. Malac.  
Soc., Vol. X., pt. 3, 1912, p. 222.

Habitat—Circular Head. Ten dead specimens, some  
of three, the others of four whorls.

The above shells have been kindly examined by C. J.  
Gabriel, Esq., who has confirmed the identification.

## NOTE ON THE MOLLUSCA OF CIRCULAR HEAD.

In the Illustrated Index of Tasmanian Shells issued in 1923 by the late W. L. May, the habitat of a large number of shells was assigned to the East or South coasts (or to both), the implication being that they had not been reported from elsewhere in Tasmania. In the course of annual visits for the last twelve years to Circular Head, I have there gathered upwards of seventy of these species, and I append a list as likely to be of interest to anyone studying the distribution of Tasmanian mollusca.

- Neotrigonia margaritacea*, Lam.
- Lima strangei*, Sow.
- Cochlodesma angasi*, Crosse.
- Thraciopsis elongata*, May.
- Myodora brevis*, Sow.
- Myodora ovata*, Reeve.
- Myodora tasmanica*, T.-Woods.
- Venericardia columnaria*, Hed. & May.
- Codakia minima*, T.-Woods.
- Codakia tatei*, Angas.
- Macrocallista diemenensis*, Hanley.
- Macrocallista kingii*, Gray.
- Antigona lagopus*, Lam.
- Bassina paucilamellata*, Dunker.
- Macoma mariae*, T.-Woods.
- Venerupis exotica*, Lam.
- Pseudarcopagia botanica*, Hedl.
- Gari kenyoniana*, Prit. & Gat.
- Panope australis*, Sow.
- Pholas obturamentum*, Hedl.
- Macroschisma tasmaniae*, Sow.
- Clanculus undatus*, Lam.
- Liotia micans*, Adams.
- Liotia densilineata*, Tate.
- Merelina cheilostoma*, T.-Woods.
- Epigrus cylindraceus*, T.-Woods.
- Rissoina elegantula*, Angas.
- Rissoina gertrudis*, T.-Woods.
- Rissolina angasi*, Pease.
- Ataxocerithium serotinum*, Adams.
- Seila crocea*, Angas.
- Cerithiopsis trisculpta*, May.
- Austrotriton parkinsonius*, Perry.
- Olivella leucozona*, Ad. & Ang.

*Ancilla marginata*, Lam.  
*Marginella bucca*, Tomlin.  
*Marginella formicula*, Lam.  
*Cancellaria purpuriformis*, Kuster.  
*Duplicaria ustulata*, Deshayes.  
*Parviterebra brazieri*, Angas.  
*Apaturris alba*, Petterd.  
*Apaturris costifera*, May.  
*Pseudoraphitoma bilineata*, Angas.  
*Nepotilla triseriata*, Verco.  
*Fasciolaria fusiformis*, Valenc.  
*Fusinus novæ-hollandiæ*, Reeve.  
*Mitra bellapicta*, Verco.  
*Mitra legrandi*, T.-Woods.  
*Mitra pumilio*, May.  
*Mitra strangei*, Angas.  
*Pyrene beddomei*, Petterd.  
*Æsopus cassandra*, Hedl.  
*Murex angasi*, Crosse.  
*Trophon brazieri*, T.-Woods.  
*Trophon fenestratus*, Tate & May.  
*Trophon rudolphi*, Brazier.  
*Leuconopsis pellucidus*, Cooper.  
*Leucotina concinna*, Adams.  
*Syrnola bifasciata*, T.-Woods.  
*Syrnola harrissoni*, Tate & May.  
*Syrnola tasmanica*, T.-Woods.  
*Odostomia portseaensis*, Gat. & Gab.  
*Turbonilla acicularis*, Adams.  
*Turbonilla beddomei*, Petterd.  
*Turbonilla fusca*, Adams.  
*Eulima columnaria*, May.  
*Eulima mayii*, Tate.  
*Eulima munita*, Hedley.  
*Eulima topaziaca*, Hedley.  
*Cylichnina atkinsoni*, T.-Woods.  
*Cylichnina iredaleana*, Hedl.  
*Cylichnina pygmaea*, A. Ad  
*Rhizorus rostratus*, Adams.

# DEFINITION OF A NEW FOSSIL CHITON.

By

EDWIN ASHBY, F.L.S., Etc.

(Communicated by Clive Lord.)

(Read 10th June, 1929.)

Plate I.

*Pseudo-ischnochiton*, n. gen.

The above generic name is proposed provisionally for the reception of a new fossil Chiton which I am describing under the name *Pseudo-ischnochiton wynyardensis*; which species I designate as the type of the above new genus.

*Definition*.—Median valve only, distinguished by extremely thin shell, tegmentum almost unsculptured except for a strongly raised rib and slight radial ribbing; pleural area unusually broad and tegmentum much bowed forward on either side of the jugal sinus; sutural laminae reduced to a narrow extension of the articulamentum bordering the anteriorly bowed tegmentum; insertion plates absent wholly or in part.

*Pseudo-ischnochiton wynyardensis*, n.sp.

(Plate I., figs 1a., 1b.)

*Introduction*.—Mr. Francis A. Cudmore, to whose earnest collecting we are indebted for so many discoveries in Fossil Mollusca, has placed in my hands for description a single median valve of an undescribed fossil Chiton. It is quite unique in several respects; at first I purposed placing it provisionally under the family *Ischnochitonidae*, but on re-examination under 65 magnifications, I could find no evidence of the breaking off of the insertion plates, and was driven to the conclusion that it never possessed insertion plates; we are compelled to consider it a primitive species. Except for the absence of insertion plates (a feature that is common to the genus *Lepidopleurus* and Palaeozoic forms) it shows no



*Pseudo-ischnochiton wynyardensis*, n.sp.

(a) Upper side; (b) side view.



affinity with the *Lepidopleuridae*, and in other respects appears unrelated to any of the living forms. Until added data are available by the discovery of the end valves, I propose placing it under the above new genus, the name being suggested by its general appearance, which in the thinness of the shell and general shape simulates the *Ischnochitonidae*; but the peculiar forward development of the tegmentum, the reduced sutural laminae, and absence of insertion plates, show it to be widely removed from that family.

*Upper Side*.—Median valve, shell thin and fragile, in fact, so thin that I at first feared that the tegmentum had been weathered away, but under the closest examination there is no evidence of this, and the fact that a row of perforations exist in the under side immediately below the diagonal rib, which evidently were the apertures through which the nerve fibres passed, makes it clear that the articulamentum has not been flaked off; shell highly arched not ridged, bent downwards at the beak, dorsal area well defined, of medium width, the sides of this area forming two sides of an isosceles triangle, longitudinally ridged with narrow, shallow, widely spaced ribs; the side slope of this valve is steep, and owing to the elevation of the arched dorsal area the pleural area appears slightly concave, but this is more seeming than real; the tegmentum is bowed forward very strongly in a unique manner, the sinus between being very deep, the only sculpture consists of concentric growth grooves, a strong, though narrow diagonal rib which is more or less broken by transverse sulci, this in a very perfect specimen would probably under a low power suggest sub-granulation; the portion of the valve posterior to the diagonal rib is narrow, about a quarter the size of the pleural area, and this portion but for the diagonal rib is not raised, but shows towards the outer margin shallow radial ribbing, the posterior margin has broken away except near the beak where the margin is narrowly thickened; anterior to the diagonal rib is a slightly raised fold only visible under lateral lighting.

*Under Side*.—Deeply scooped out under the dorsal area, the callus forming a strong ridge which is much bowed, the space between the callus and the posterior margin is on either side also deeply scooped out; owing to the extreme thinness of the shell the line of demarcation between the tegmentum and the articulamentum is a little obscure, and what I take to be the sutural laminae are very narrow, forming a narrow marginal extension of the bowed tegmentum;



the sinus between, as before stated, is fairly broad and deep. The insertion plate is absent, at first I concluded it had broken away on either side, but having re-examined the margin under 65 magnifications I have concluded that the shell never possessed insertion plates, and that the extension of the articulamentum which forms the sutural laminæ, ceases at the callus; the tegmentum is folded over at the beak, the anterior margin of this infolded portion consists of a well-defined, narrow, smooth, callus ridge.

*Locality*.—Table Cape, Wynyard, Tasmania; Tertiary (Janjukian).

*Measurement*.—6 x 3.5 mm.

#### EXPLANATION OF PLATE I.

Fig. 1.—*Pseudo-ischnochiton wynyardensis*, n.sp. Holotype, median valve, (a) upper side, showing general shape and diagonal rib, x 6; (b) side view same valve, showing diagonal rib and arched jugum, x 7. National Museum, Melbourne, No. 13,498.

## TASMANIAN STONE CULTURE.

SOME NOTES ON DISTINCTIVE TYPES, SPOKESHAVES, BORERS,  
AND CHIPPING TOOLS, AND THEIR PROBABLE USAGES.

By

R. W. LEGGE, Cullenswood.

Plates II.-V.

(Read 12th August, 1929.)

Amongst the various and more or less well-defined types of Tasmanian stone implements which have been engaging the attention of students for some time past, there are two distinct and decidedly specialised forms which stand out conspicuously from all the others as having been fabricated for certain definite purposes.

In the following notes they will be termed respectively Spokeshaves and Borers, and it is proposed with the help of two or three plates to give a short description of several series which are fairly representative of the types.

So persistent are these two forms throughout the whole range of Tasmanian stone implements, and so regularly do they conform to type, that, although this is not by any means the first instance wherein they have been described, it is thought that students may still derive some considerable interest from having series of selected flakes exhibiting remarkably well re-touched edges brought directly under their notice.

These types are the more interesting also, in that they have survived right down through the ages from the Middle Palæolithic Period, as indeed practically the whole Tasmanian Lithic Industry has done, revealing, as it undoubtedly does, the most remarkable analogies to the types constituting the chief features of the Mousterian and post-Mousterian Flint Culture.

Taking the so-called Spokeshaves first, a series of 53 has been chosen, which is illustrated on Plates II. and III.

The chief, if not the only, purpose for which these implements were made and used, was for smoothing down spears and waddies after having carefully charred the shafts first to remove the outer and softer layers of the wood, and for trimming off any slight protuberances which might be present.

The writer has found this type occurring in much greater numbers in the ancient native camps on the East Coast than elsewhere, in the Midlands for instance, probably because the material for weapon making was much more plentiful in the dense Tea-tree scrubs along the banks of the coastal rivers, and around the margins of the lagoons. It is not unlikely that during the periodical visits of some of the tribes, the Ben Lomond, for instance, to the Coast in the winter, the men obtained the best shafts for their weapons from these sources. The fact remains that nearly all the specimens comprising the series chosen to illustrate this paper, have come from the great camping grounds at Long Point and Beach End, some 2 miles north of Bicheno; the type has been found to occur in a lesser degree also in the camps along the coast reaching southwards from Oyster Bay to Grindstone Bay, opposite the northern end of Maria Island. It is, of course, more than likely that other collectors than the writer who have entered this field previously, notably, the late Ernest Westlake, Dr. Crowther, and others, have taken up numbers of these Spokeshaves.

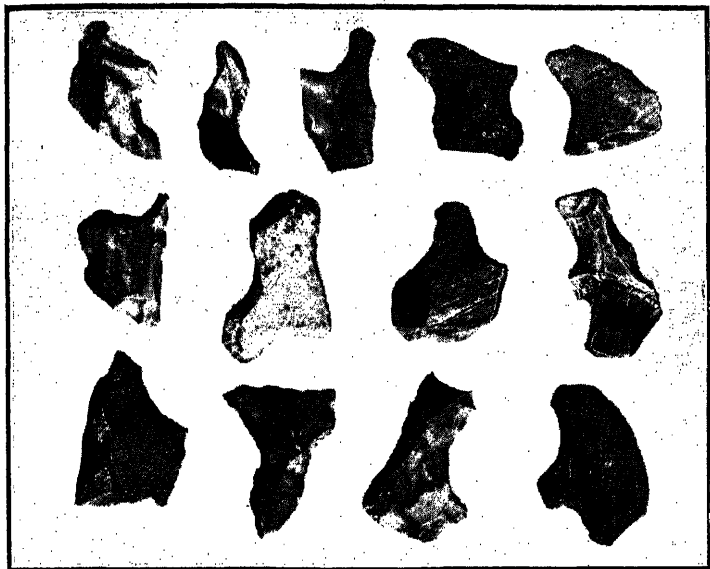
In quite a fair number of instances we find the Spokeshave and the Borer merging in the one specimen, where two concavities appear on the one flake opposite each other, the adjacent edges running together to form a pointed common extremity. The point thus formed, though, is usually more of a drill than that which is found on the Borers or, as they have been called, "Duck-bills" with which we have to deal in this paper.

#### BORERS OR "DUCK-BILLS."

Whilst it is quite reasonable to ascribe the foregoing uses to the Spokeshave, which, from its very shape, makes them fairly obvious, it is neither easy nor prudent to form any definite conclusions as to what were the actual purposes the natives put these so-called "Duck-bill" implements to.

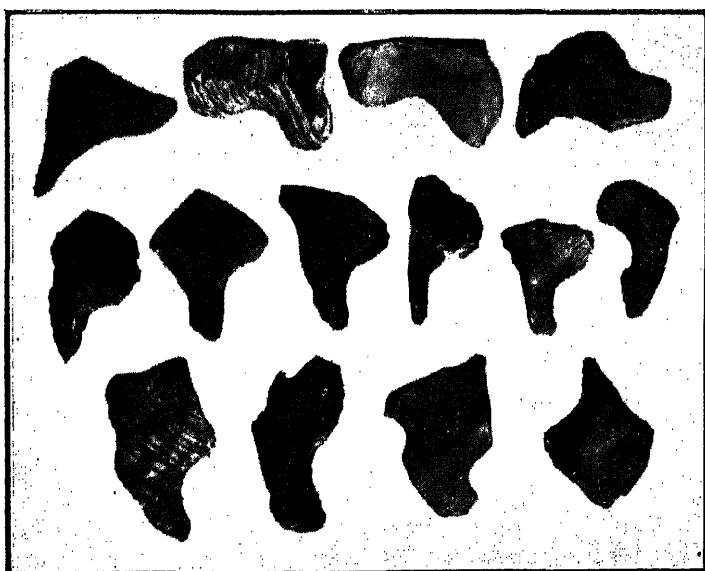
The form is decidedly a conventional one, and there must have been some very definite object in view when it was so persistently fashioned. The spatulate extremity in nearly every case creates the impression that the intention was to have a tool suitable for work for which the finer points or piercers, which are by no means uncommon, were not just what was required.

A review of the 17 specimens selected to illustrate the type will clearly show how faithfully the duck-bill form was adhered to. The type may be said to be one, if not the most



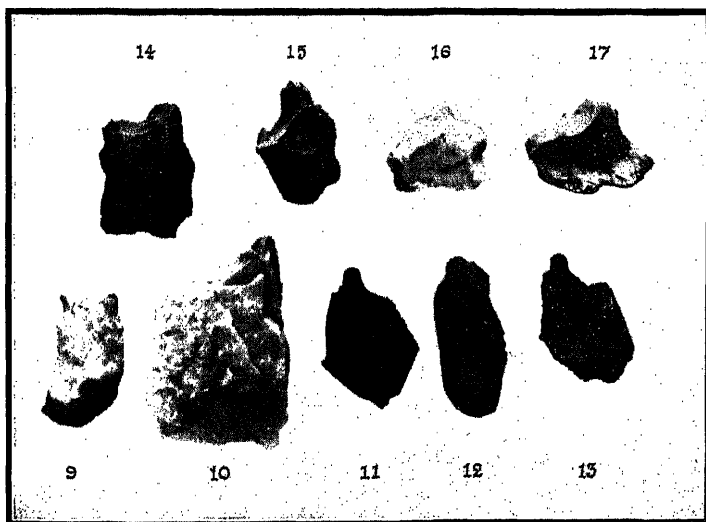
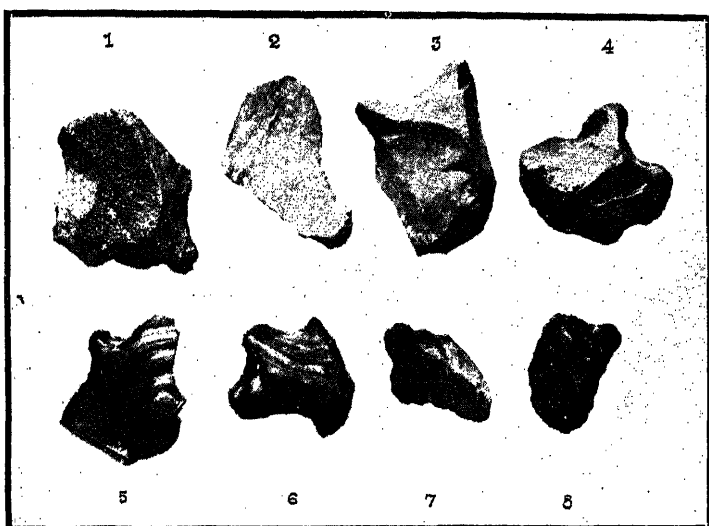
Tasmanian Stone Implements.





Tasmanian Stone Implements.

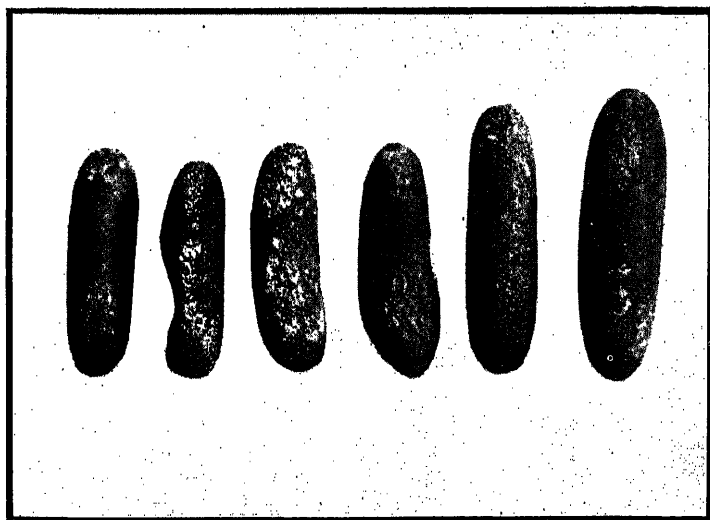
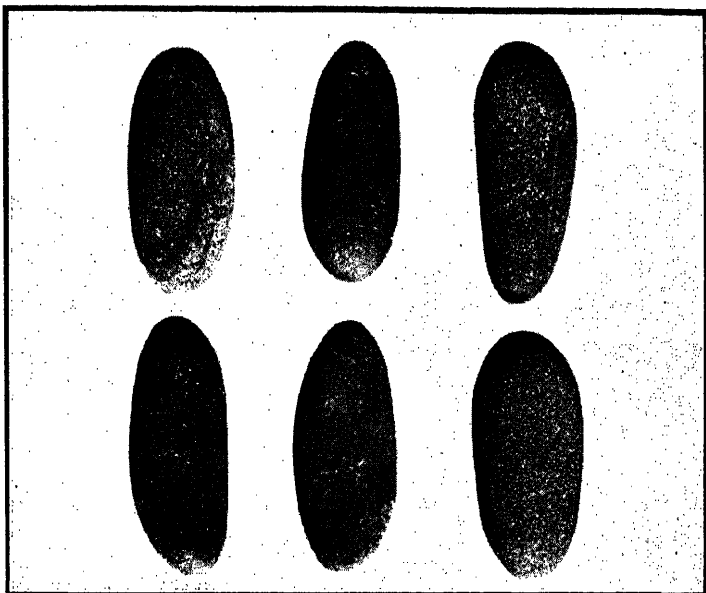




Tasmanian Stone Implements.







Tasmanian Chipping Tools.



dominant of those figuring in Tasmanian Stone Culture; occurring as it does in miniature or pygmy form, a series of these having already been described by the writer in an earlier paper.

In the series chosen, if we look at Nos. 9, 10, 11, 12, and 13, figured on Plate IV., it will be seen that the point or "duck-bill" forms the sole feature of the flake, that is so far as any secondary treatment is concerned. In Nos. 1, 3, 4, and 5, on Plate IV., we have four (4) particularly characteristic specimens having bold points, three of them flanked on either side by concavities, more or less well defined, but these features do not constitute the main ones, and are but the results of the intentional fashioning of the "duck-bill" itself. That the two features do frequently occur conjointly cannot be denied, but where the delicate chipping of the point itself is so very apparent, as it is in most instances, the conviction becomes strong that the formation of this feature was the main object in view.

No. 6, Plate IV., shows an attempt to form a double point.

The workmanship of the point on No. 8 is particularly delicate, and such finish could only have been accomplished by skilful pressure-flaking, as the facets around it are very minute, and yet so placed as to leave scarcely any traces of a saw-like edge on the under-side; attrition by wind-driven and ever moving sand will doubtless account for much of this smoothness of edge.

In No. 16 we have a specimen of white porcellanite which is of attractive appearance and shape, the latter lending itself admirably to a secure finger and thumb grip. No. 17 is a fine example of the type, though much broader across the point than usually seen, the tool having been fashioned like many others for the sake of the duck-bill alone.

Having arrived thus far with a description of this interesting type, let us now hazard a few conjectures as to what was its chief usage. For what purpose or purposes were these so-called "Duck-bills" made? Why do they constitute such a prominent type in Tasmanian lithic culture? Certain it is there was a very definite use for them, and so far as the making and shaping of spears and waddies is concerned, it may be safely affirmed that this is not likely. From what is known of Tasmanian native crafts such as basket and necklace making, we may be sure that this

implement played no part in these. For the gathering together of the edges of the kelp water-pitchers, the natives would probably have used a fire-hardened and pointed skewer, first piercing the holes with a sharp stone *point*. The "Duck-bill" would not have been suitable for this operation, though again we must not overlook the fact that a blackfellow will pick up the nearest and handiest thing he can lay his hands on to effect his purposes.

The usage for this tool which appeals to the writer as being the most likely one, is in connection with Fire-making.

In Ling Roth's *Aborigines of Tasmania*, facing page 83, there are two illustrations depicting two fire-drills and socket-sticks.

One pair of these was presented to Sir John Lubbock by G. A. Robinson, and the other, from the Barnard Davis collection, reposes in the Pitt-Rivers Museum at Oxford. In referring to these socket-sticks, the author says that "it was probably the flower stem of *Xanthorrhœa* that was used, as the stem has a pith-like centre."

Now, a glance at these socket-sticks at once suggests that the holes or sockets appearing along them must have been first started with some boring tool, for it is not reasonable to suppose that they could have been made or begun with the drill-point itself.

No doubt a wood-dust priming was first introduced into the socket before drilling commenced, and from their distinctive shape, it seems extremely likely that the "Duck-bill" was used to gouge out the recess or socket to hold the priming and provide a close fitting place or hole to work the drill in.

In Péron's description of a native "tomb" visited in Oyster Bay, he says: "On the inner surfaces of some of the 'best and largest pieces of *bark*: some characters were 'crudely marked similar to those which the aborigines 'tatued (*sic*) on their fore-arms." Duck-bills may possibly have been used for graving these marks.

The specimens selected for this paper are all from East Coast stations, ranging from Orford to Scamander River.

#### CHIPPING TOOLS.

The study of Tasmanian Lithic Culture, to be anything like complete, should include descriptions, not only of the various types of scrapers and borers, but also of the stone tools with which these were made and finished off.

The flakes struck off the matrix or core-stone with a more or less heavy hammer-stone, did not always have the sharp fortuitous edge needing no further treatment to make of them useful scrapers or knives. It was in the preparation of those flakes which needed their edges sharpening that the Tasmanian implement-maker showed himself to be the equal in skill to any of the Palæolithic peoples who either preceded or were cotemporaneous with him.

The keen student, when examining a series of Tasmanian scrapers, cannot help but admire, even if he does not marvel at, the fine secondary treatment which the edges of many of the pieces coming under his scrutiny will exhibit, revealing a high degree of skilful technique in their finish.

This finish, or, as it is usually termed, secondary treatment, had to be effected with some kind of a stone tool, and it is the object of this paper to give a short description, aided by photographs of a series of what may be called "Tool-stones" which the writer believes to have been used almost exclusively for this purpose.

These tool-stones have been taken up in different ancient camping grounds along the East Coast, and are by no means common. (See Plate V.)

They are all of the same type, elongated water-worn pebbles, from  $2\frac{1}{2}$  to  $3\frac{1}{2}$  inches long, and averaging  $1\frac{1}{2}$  inches in width.

They all show the same traces of wear in the same spot, namely, on the edges near the extremities, a little to the rear, and all of the twelve specimens selected for description herein, have both edges at either end distinctly worn, a more or less flattened surface being in evidence at these points.

This wear is the result of continual glancing blows struck at the edges of the flakes away from the hand in which the latter were held, and aimed at the opposite edge to that on which the chipping appears. Considerable care, skill, and accuracy must have been employed in the delivery of these blows, although when one learns just how it was done, it does not appear to be so difficult.

Flat ovate pebbles were also used for this work, but the type here described seems to have been the favourite, and possibly was that best suited for the purpose, which must not be confused with that of pressure-flaking, a separate art in itself.

# METHOD OF MOUNTING STONE TOOLS ON KOONDI. TRIBES EAST AND NORTH-EAST OF LAKE EYRE.

By

GEORGE AISTON, Maree, South Australia.

(Communicated by R. W. Legge, Cullenswood.)

Plates VI.-IX.

(Read 12th August, 1929.)

The gum used for mounting constituted a very important article of barter. The natives with their usual queer dislike for anything that could be obtained in their own country would collect and make into balls the gum that was most useful in their country and barter it away at their periodical markets for gum collected in some other part of the country.

They very jealously guarded the secret of the origin of any of the various gums, so that any stranger coming to the country would have to search until he could find for himself. Although all of the camp would know what he was looking for, no one would give him the slightest hint.

A boy, who entered my employ some years ago, came from about Alice Springs, and being energetic wanted to make some weapons for himself, but first he had to find the materials to make tools. I well remember his hunting, first for suitable stone, then for the right sort of wood, and finally his search for gum for mounting. In his country the proper gum was obtained by burning the spinifex. He tried that here and got nothing. This nearly disheartened him, but he persisted until I told him of the mindry bush, and acting on my hint he succeeded in getting the necessary gum. In my opinion, mindry was the best of all of the gums used for tool mounting; it is tough, hard, will stand practically unlimited re-heating, and can be found almost anywhere in this country. The Salt Creek branch of the Wonkonguru pinned their faith on beefwood gum. This was very easy to work, but was susceptible to climatic conditions; damp weather made it sticky, and hot weather made it soft. If left out of use for a month in hot weather it would crack to pieces.

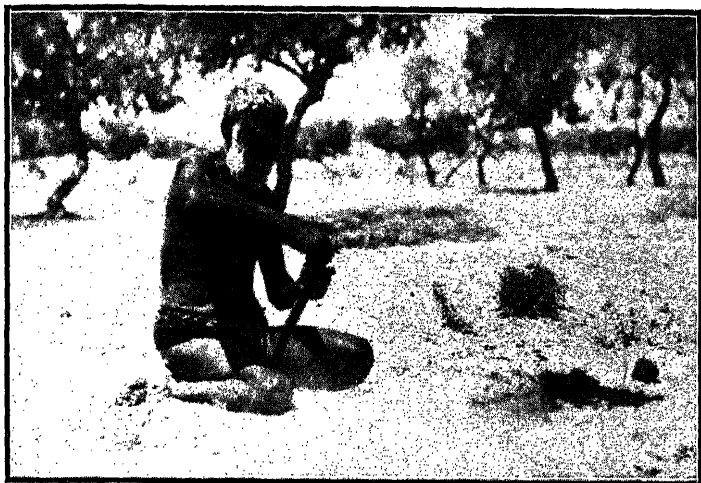


Fig. 1. Mounting Stone Tools on Koondi, Lake Eyre Region.



Fig. 2. Mounting Stone Tools on Koondi, Lake Eyre Region.





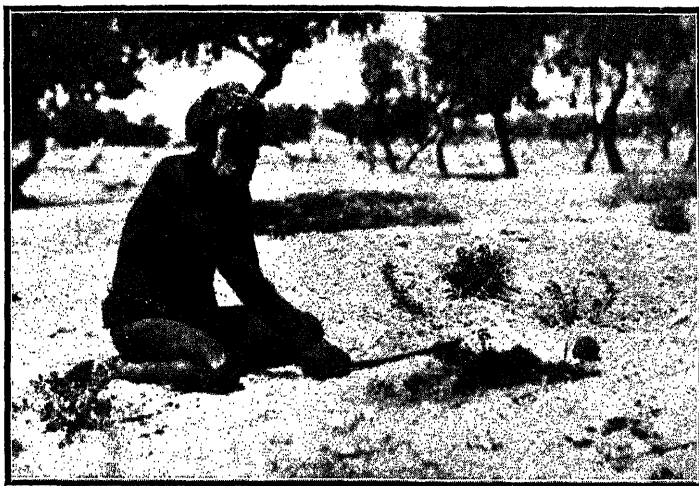


Fig. 1. Mounting Stone Tools on Koondi, Lake Eyre Region.



Fig. 2. Mounting Stone Tools on Koondi, Lake Eyre Region.



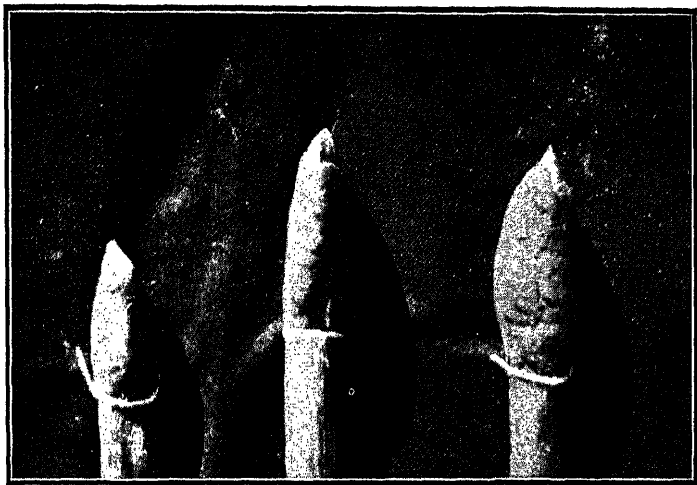


Fig. 1. Mounted Tuhlas, Lake Eyre Region.

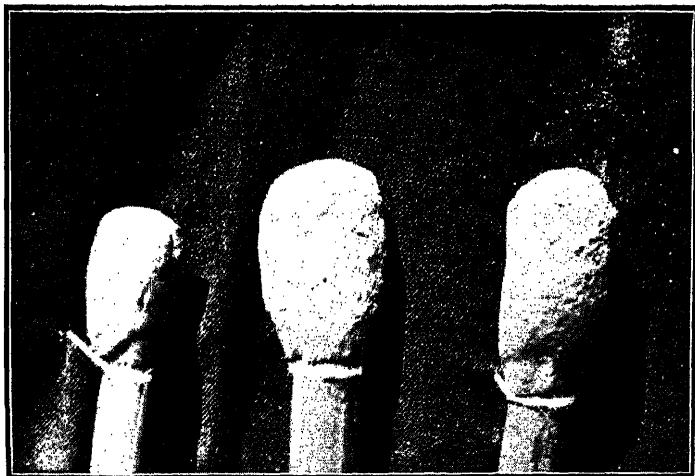


Fig. 2. Tuhlas, Lake Eyre Region.



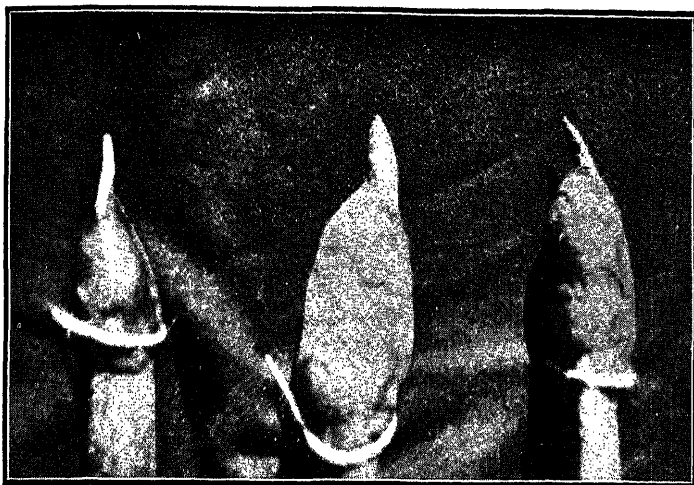


Fig. 1. Mounted Pirries, Lake Eyre Region.

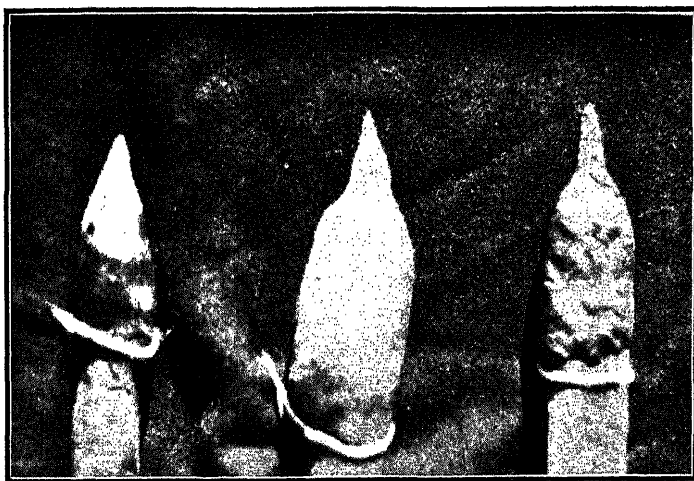


Fig. 2. Mounted Pirries, Lake Eyre Region.



*Spinifex* gum, known locally as "pooya," was very hard and tough, but would only stand re-heating two or three times; after that it would set hard and would burn before it melted.

The mindry roots went down to great depths to water. Well sinkers have told me that they have come across green mindry roots at a depth of forty feet from the surface. This possibly explains why the mindry grows at practically all times. Just at present, although we have not had more than thirty points of rain during the last nine months, the mindry in places is still green and fresh.

It was the women who usually collected the mindry roots. They would sink a hole slanting down to a depth of about three feet, near the mindry bush, until they uncovered the roots, which are usually about an inch thick, and always going straight down. They would work in a face into the bush, breaking the roots off in lengths of about two feet. When they had a load big enough to satisfy them they returned to camp. Here the mindry roots were sliced or scraped up into a *pirra*, and afterwards placed on the hot ashes. This caused the gum or resin to melt out and run into the ashes. It was then collected, and rolled into a ball with the hands, the worker continually licking his hands to prevent the hot gum from sticking. It was then rolled up with a mixture of kangaroo dung to increase its toughness, and was then ready for use.

The accompanying Plates and figures will illustrate the method of use. The ball of gum is re-heated near a fire, a piece is then pinched off, the fingers being kept wet by licking all of the time. The piece is then stuck on one end of the *koondi*, as shown in Plate VI, fig. 1. By this time the gum has set, so it is re-heated over the fire, and then is pressed firmly on to the end of the *koondi*. At this stage (Plate VI, fig. 2) it has the appearance of a knob.

It is then re-heated and the tool is pressed firmly into the gum, care being taken that the base of the tool rests on the end of the *koondi*.

It is again re-heated, and the tool is finally smoothed into place.

In Plate VII, fig. 1, will be noticed the little bank of sand built to protect the worker's hand from the heat of the fire.



Plate VII., fig. 2, shows the workman on the left in the act of finally smoothing off a mounted tuhla, and the figure on the right is waiting for a tool, visible in the fire, between the two figures, to soften enough to put it through another stage. He is holding in his hand a koondi on which he afterwards mounted pirries. Between his knees will be noticed a coolkie or hammer stone, and opposite his right knee can be seen the ball of gum. A wadna or digging stick is visible between the two figures towards the back ground, and a ball made of the fibres of the sand hill broom bush. The man on left has a pirrha (bowl) between his legs.

Plate VIII., fig. 1, shows a close up of mounted tuhlas, side view.

Plate VIII., fig. 2, shows the same tuhlas, back view.

Plate IX., fig. 1, shows side views of mounted pirries. The one on the right was mounted with beefwood gum. I picked this up in a deserted hut on the Diamantina River in 1913. The tool on the other end of the koondi was a piece of steel bound on with emu sinew.

Plate IX., fig. 2, shows front views of the same pirries.

MAGIC STONES OF THE TRIBES EAST AND NORTH-  
EAST OF LAKE EYRE.

By

GEORGE AISTON, Maree, South Australia.

(Communicated by R. W. Legge.)

Plate X.

(Read 12th August, 1929.)

Any stone that was unusual was picked up by the tribesman and sooner or later was endowed with magical qualities. Probably when first brought in, no notice would be taken of it, but some chance would perhaps ensure a plentiful supply of food soon after the stone was found, and a conference of old men would be called to try and ascertain why it was that this supply became available.

To the native there was no effect without a cause, and it would be only a little while before some one remembered the strange stone that had been found. No one could give any reason for the strange stone, and no one could account for the unexpected supply of food; therefore the two unexplained things must have some relation to each other, and the stone became a magic stone.

I have not the slightest doubt that the use of clear gypsum as rain stone and the many attempts to dissolve it into water are caused by the fact that at some remote time a piece of clear ice was found, left over from the very infrequent frosts that occur in this country. A rain probably followed the finding of the piece of ice, possibly while the natives were handling it. There were the two things unexplained, the hard water, or clear stone to the native mind, and the unexpected rain. A rain is nearly always accompanied by a rise in temperature in this country, so the ice would be melted before the rain stopped, therefore to the native mind the clear stone that melted must be responsible for the rain, and ice being hard to obtain and clear gypsum plentiful they have ever since been trying to dissolve it and make rain.

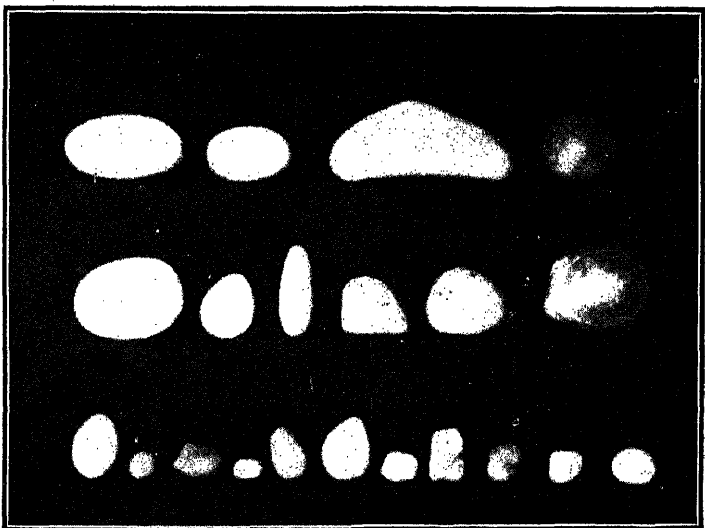
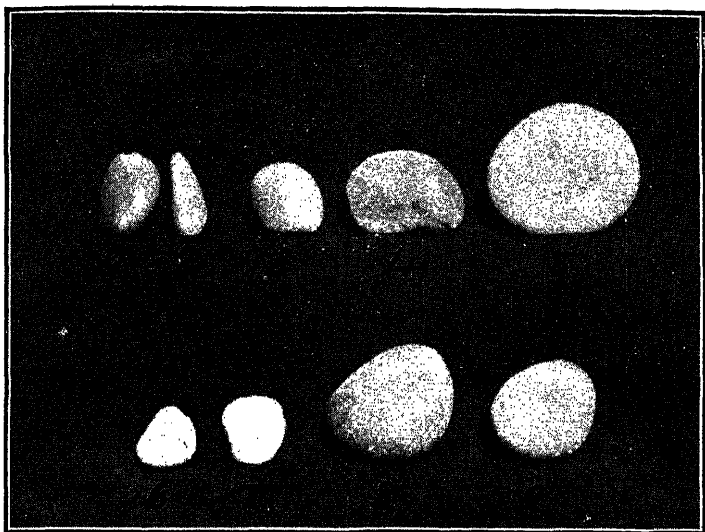
One of the accompanying photographs was taken many years ago, and several of the stones have passed from my possession.

Plate X., figs. 1 and 3, represents the seed of the yowa (*Cyperus* or onion grass), a plant with a bulbous root that grows very quickly after a rain. The bulbs are a favourite food, and are eagerly sought after.

Directly it starts to rain the whole tribe go out to a likely sandy place and broadcast these stones over as much ground as they can cover. There is no necessity to plant them thickly, one every twenty square yards or so will ensure a plentiful supply. After the yowas are grown the stones will be collected and returned to the pillies (string bags) to serve another turn.

Nos. 2 and 16 are known as Mooras yakhurra, or Mooras' teeth. The Yaurorka have a tradition that a big lizard caught and ate one of their number while he was swimming in the Cooper. They caught the lizard at near Lake Hope, and after knocking out all of his teeth they let him go. The teeth were buried at Lake Hope (pando), and in the course of time a legend grew up that any one who could get one of these teeth was safe from the cuddimukra (legendary beasts that live in the deep waters).

The original teeth having been used up some one found a smooth, pointed stone, not unlike a crocodile's tooth. This was tried by some one who had to cross the water. Having got across safely he gave the credit to the stone, and any stones near this shape were deemed magical. They are very rare, most of the country being covered with red sandstone gibbers, so possibly those few that are discovered have been brought here. There is no doubt that they were treasured; the one numbered 16 has a high glassy polish on it that must have taken hundreds of years of carrying to attain. No. 4 is a charm for ensuring success in the search for coories or fresh-water mussels. It was given to me some years ago by an old blackfellow who assured me that it was a coorie that the Mooras had turned to stone. It looks more like a petrified bean seed, but I think it has only acquired its shape by sand attrition. The old fellow who gave it to me, Tarkarawikarie, assured me that if I took it with me on the trip to the Cooper on which I was going at the time, the mussels would come out of the mud for me if I held it near the mud banks.



Magic Stones from Lake Eyre Region.



Nos. 5, 8, and 9 are mullaricardi, or pounding stones used in the ceremony of planting wirrha bush seeds.

The wirrha (*Acacia salicina*) is used to provide the ash to mix with the pitchuri or native tobacco. The fresh young green leaves make a better ash than the older drought-dried leaves. When the trees were getting dry the old men formed in a ring in some likely place in the sandhills and placed a few round white quartz pebbles on the sand. They then took one or two genuine seeds, each, of the wirrha tree, and pounded them up between the mullaricardi, the pounding beat time to the song of

Charrila charrila Koppara Charrilla, charrilla koppara Nunta  
 plant plant root plant plant root grow

Dr. Horne, *Savage Life in Central Australia*, transposed these words and made Charrilla to mean root and koppara to mean plant. The famous bartering place for the tribes, Kopperamanna to the white people, and koppara murra to the natives, gets its name from root hand (as all of the fingers lead to the root of the hand, so all tribes gather at koppara murra).

The white quartz pebbles were left on the sandhill, and very shortly afterwards a fresh lot of wirrha would grow. The pebbles would then be picked up and put back into the pillies for use at another time.

Nos. 6 and 7 were the pebbles used in the above ceremony. There is no white quartz in this country, so these stones must have been brought up from near Marree, they are very plentiful there.

Nos. 10 and 11, 13, 14, 17, 18 were stones that were sucked out of various people by the medicine men (koonkis); 10 and 11 have been made, the signs of the grinding to the very symmetrical shape being very visible; 13 is just a brown pebble, worn smooth and polished with long carrying; 17 is very like a petrified cockle in appearance—it was given me by a medicine man who claimed that he had sucked it out of the hip joint of a woman who was suffering from rheumatism. Whatever else he did to the woman, he got her on her feet again, and she is still alive; he treated her about five years ago, at a time when every one, myself included, expected her to die.

No. 18 is just an ordinary pebble, as always worn smooth with carrying.

No. 12 has something to do with the Kirra maker murdu or totem, but I cannot quite grasp what relation it has to the Moora. It is not the emblem of the Mooras. There were two of them. Their emblem was a slender cylindro-conical stone each, but this stone, so the blacks tell me, is "cousin belong Kirramurakoo. Himshow which Moora "them two stones belong."

The two women who were the ancestors of the Kirra maker murdu became Mooras because they killed another Moora who was notorious for his molestation of women. He worried the two women, and they got rid of him somehow, then went back to their camp, where they made a boomerang (kirra) each, and when the Moora annoyed them again they killed him with the kirras they made.

The stone is five inches long by about 2 inches wide at its widest part, and was found about eighteen miles west of this place.

The present holder of the Kirra maker Moora stones was very anxious to get this, as he says it completes his Moora, this part having been lost in his grandfather's time.

No. 15 represents some seed unknown.

No. 19 ensures to the possessor a plentiful supply of eggs. I found it among the bones of a skeleton of a man who had been shot at Neaylons Swamp, near Mungeranie. Directly I picked it up I showed it to a blackfellow who was with me. He very promptly pocketed it, and I had to struggle with him to get it back. He was very sulky with me for a couple of days, but finally brought a deputation of old men over to me to try and persuade me to hand it over to him, but the old men advised me to keep it myself. They assured me that I would always have a plentiful supply of eggs as long as I kept it, but, somehow, it does not work for me.

Nos. 20 to 30 represent various seed stones. Most of the white pebbles are wirrha bush seeds, but the use of the darker ones is unknown. Their highly polished appearance, and the fact that they are foreign to the country, is all that makes them magical.

THE BIOLOGICAL CONTROL  
OF  
NOXIOUS WEEDS.

By

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Chief of the Division of Economic Entomology,  
Commonwealth Council for Scientific and Industrial  
Research.

(Read 14th October, 1929.)

Plates XI.-XVIII., and One Text Figure.

In the rush and hurry of this present age, in which the speed of the world's evolution is greater than ever before, few opportunities are given to the ordinary man to pause and look backward, if only for a few moments, so that a little piece of the past may be viewed, and thereby a truer perspective of the present gained. To-night we are gathered together in this hall to do honour to a great pioneer of biology in Tasmania; and you have done me the very great honour of asking me to deliver this, the third R. M. Johnston Memorial Lecture, in memory of that pioneer. My predecessor in this lecture, Professor Wood Jones, whom, I am sure, we are all delighted to welcome back once more to Australia, said that the best way to honour the memory of this great man was to give of one's best in return. This I shall endeavour to do to-night.

Looking back to the time when R. M. Johnston lived and worked, I think the most striking thing was the immense field of research covered by the biologists of that time. A man could, if he chose, take the whole of Biology as his subject, and do original work in many diverse groups. There were even professors at some well-known Universities, who taught their students the three subjects of zoology, botany, and geology, and taught them well, too. Nowadays the various branches of science have enlarged their boundaries to such an extent that this wide field is no longer possible for any single human mind. As the boundaries of our knowledge extend, as the blank wall of ignorance is pushed farther and farther back, the conquered territory spreads out before us in every



direction, and the man of science of the modern world has to choose his exact location in this great domain earlier, and set his direction of original exploration far more exactly, than did the great biologists of the past. Thus the modern scientific man is becoming more and more specialised in his knowledge; as the human brain remains much the same size as before, and the human mind is still only capable of holding a limited content of knowledge, he has to lose on the wider outlook of his predecessors, in order to gain the greater degree of specialisation in the narrower field.

At the present day, the subject of Entomology, which is only one of many branches of Zoology, is probably much greater in its content of knowledge than was the whole science of Zoology a hundred years ago. It is almost impossible to-day for any one man to cover the whole field of Entomology; we can only be specialists in some particular section of it, in which we work with the hope of wresting further secrets from Nature and turning them to the use of mankind. It has been my good fortune to work in several such fields, and it has seemed to me right and proper that, in striving to follow up Professor Wood Jones's dictum, I should select one such field suitable to the occasion, and give you a complete summary of the work so far done in it by modern workers. As the world looks more and more to Science to carry it forward on its evolutionary course, and needs more than ever before that scientific methods should be applied to the solution of its most pressing economic problems, I have selected that economic aspect of the science of Entomology in which I am most interested, as the subject for this lecture, viz., "The Biological Control of Noxious Weeds." I think that there is also another good reason for the choice of this subject, in that, of all countries in the world, Australia and New Zealand appear to have suffered most from the free spread of noxious weeds, and have the greatest need of assistance from science in controlling them.

I propose to divide the subject into five sections, as follows:—

- (1) The General Principles of Biological Control of Noxious Weeds.
- (2) The Early History of Biological Control of Noxious Weeds.
- (3) The Biological Control of Prickly Pear in Australia.
- (4) The Biological Control of Noxious Weeds in New Zealand.
- (5) The Biological Control of Noxious Weeds in Australia.

## I. THE GENERAL PRINCIPLES OF BIOLOGICAL CONTROL OF NOXIOUS WEEDS.

A weed has been well defined as "a plant out of place." Some weeds, when introduced into new countries like Australia or New Zealand, appear to have an almost infinite capacity for getting "out of place"; the term "noxious weeds" is suitably applied to such as these. When a weed has such a capacity to spread that it interferes with agriculture and checks the production of crops of economic value to the community, it is certainly a noxious weed, even though it may not be proclaimed as such by law. Every State of the Commonwealth now has a long list of these noxious weeds, some proclaimed as such throughout the entire State, some proclaimed only within limited areas such as a given shire or county. In their totality, they constitute an immense problem, rendered more difficult by the sparsity of population in the country districts, and the large areas held as units of cultivation. The total loss incurred by Australia through the checking of production of cultivated crops and the immobilising of large areas of potentially productive land, must run into many millions of pounds *per annum*. Owing to the heavy cost of labour in Australia, mechanical control of weeds is only practicable on restricted areas of the more valuable types of land. Chemical control is also costly, both as regards the materials employed and the expense of application. Control by intensive cultural methods is only applicable to a limited number of types of weeds, such as those of the ordinary vegetable or flower garden; at the one extreme we have the weeds of uncultivated lands, which are gradually replacing the native vegetation; and, at the other, the "weeds of cultivation," such as Hoary Cress and Skeleton Weed, which are actually being spread more and more through the ordinary cultural methods, such as ploughing. These weeds constitute one of the greatest dangers to the future prosperity of Australia.

Weeds are spread in many ways. Many of them seed profusely, and the seed may be carried far and wide by the wind or by floods, or it may be spread by the agency of birds or animals, or it may simply be scattered intensively over a limited area. Other weeds spread by means of the underground stem or rhizome, sometimes by creeping horizontal growth, sometimes by the persistence of every scattered portion of such stem cut off and cast aside in the processes of cultivation of the ground. Many of the monocotyledonous

weeds possess bulbs, and spread by means of bulbils as well as seed. The most difficult weeds to control are those known colloquially as "double-headers," i.e., those which have two ways of spreading themselves, as in the case of the Cape Tulip, which spreads both by seeds and by bulbils.

The method of Biological Control applied to insect pests consists of the scientific study of the ecology or bionomics of the insect concerned, with a view to discovering how it is controlled in Nature, and then applying the guiding principles thus discovered to the problem of controlling it in its new environment. For instance, the Woolly Aphis of apple-trees (*Eriosoma lanigera*) is a native of America, and is controlled in that country by a number of natural enemies, the chief of which are certain species of ladybirds, hover-flies, and a small internal parasitic wasp known as *Aphelinus mali*. Woolly Aphis has been spread from America all over the world, wherever apples are grown, and was for a long time one of the major pests of apple orchards in Australia and New Zealand. My first attempt at controlling this pest in New Zealand was made with the ladybird, *Hippodamia convergens*, which is considered highly effective in California. This attempt met with failure. My second attempt was made with *Aphelinus mali*, and proved very successful. The strain of this insect used was a mongrel or cross between races sent to me from widely separated localities in the United States of America by Dr. L. O. Howard, and it is this same strain which is now working effectively to control woolly aphis in many parts of Australia.

In the above example of biological control, we distinguish three units all connected together ecologically. First of all, there is the plant, in this case the Apple-tree; secondly, there is the insect attacking the plant, viz., the Woolly Aphis; and, thirdly, the enemy of that insect, which may be either a predator or a parasite. By *predator*, we indicate those forms, like the larvæ of ladybirds and hover-flies, which attack their prey freely from outside and devour it. By *parasite*, we indicate those forms which deposit their eggs inside the body of their hosts or place them in such a position that the host either swallows them inadvertently or exposes itself to attack from the young larva which may succeed in boring into it; in all such cases, the larva of the parasite lives and grows inside the body of its host, and thus is strictly speaking an *internal parasite*. There are also a number of cases of parasites attached to their hosts permanently but outside; these are also included under the term parasites, and are

distinguished as *external parasites*. *Aphelinus mali* is an example of an *internal parasite*.

In Nature, this process of parasitism may not end with the third unit mentioned above. A large number of cases are known in which the parasite or predator itself is attacked in its turn by a secondary parasite or *hyperparasite*, and even this, in its turn, may have enemies which may help to control it. One hesitates to use once more the well-known rhyme that so well illustrates this subject:—

“Great fleas have little fleas upon their backs to bite ’em,  
“Little fleas have lesser fleas, and so *ad infinitum*.”

But the truth is, that only one famous man has ever dared to express this thought in poetic form, and he has done it so well that his verse must suffer the inevitable consequence of being quoted to the point of becoming hackneyed.

I trust that the above example will indicate to you the sequence in Nature whereby the undue increase of one species of insect is checked by another. The principle applies so generally throughout Nature that there are indeed very few insects of any kind of which it can be said that more or less effective enemies are not known to exist. It is the study of the inter-relationships of the great mass of insect forms which is now the chief aim of the science of entomology, and this study has provided the material for some of the chief triumphs of entomology in the economic field.

Turning back again for a moment to our illustration of the Apple-tree and its enemies, I now wish to impress on your minds another idea. It is the value of the Apple-tree in relation to Mankind that rules also our valuation of the whole series of insects connected with it. *Because* the apple is a valued food for Man, the Woolly Aphis which attacks it is regarded as an *injurious insect*, and the parasite or predator which attacks the Woolly Aphis is regarded as a *beneficial insect*. These terms are applicable *only in relation to Man*. The Woolly Aphis, if it could think and reason, would certainly not class *Hippodamia* or *Aphelinus* as a beneficial insect; nor would *Hippodamia* class the Woolly Aphis as an injurious insect, seeing that it is its favourite food!

These terms, then, being only comparative, and depending entirely on the relationship existing between the plant in question and Mankind, let us now take a survey of the inverse problem, in which the plant studied, instead of being valuable to Man, is inimical to him and his primary industries. This introduces you at once to the problem which is

the subject of this lecture, viz., the *Biological Control of Noxious Weeds*. If a plant valued by Man can be protected and saved from destruction, by making use of the natural enemies of those insects which attack it, it appears equally logical to argue that a plant inimical to Man might be controlled or even possibly entirely eradicated by making use of the insects that feed upon it in Nature, provided that the enemies of those insects are first of all eliminated from the scheme. From this point of view, the insect which attacks the weed must now be considered as a beneficial insect, while its predators or parasites must be classed as injurious.

I think the comparison can now be brought home to you in a more striking form by considering the relationship of a single species of insect to two very distinct problems. The insect which I shall select is a well-known ladybird beetle, of Australian origin, *Cryptolæmus montrouzieri*. This little beetle is normally, in the larval stage, a predator on various species of native Mealy-bugs in Australia. Introduced into California, where it is reared artificially in millions every year and distributed to citrus-growers, it has proved a very effective control of the deadly Citrus Mealy-bugs (*Dactylopius* spp.) which have threatened the very existence of the great citrus industry in California. This ladybird is parasitised, in Australia, by a number of smaller insects, chiefly Braconid wasps. All such parasites were, of course, eliminated from the consignments introduced into California, and thus the potency of the insect was very greatly increased.

Now let us consider this same insect in relation to Prickly Pear control. When this problem was taken up in Australia, one of the first groups of insects studied was the Coccineal Insects, which happen to be a sub-division of the Mealy-bugs of the genus *Dactylopius*, i.e., of that very group which has been doing so much damage to citrus-trees in California. The genus was the same, but the species were different. After it had been proved by exhaustive tests that the particular species of *Dactylopius* that feed on Cactaceæ would not attack citrus or any other economic plants, these insects were introduced into Australia for the attack on prickly pear. As is now well known, one of them, *Dactylopius tomentosus*, was found to attack the pest pear vigorously, and is now being widely used in controlling it. Now the native ladybird *Cryptolæmus montrouzieri* attacks this new introduction, belonging to the genus *Dactylopius*, just as if it were one of the native species of Mealy-bug of that genus on which it normally feeds. Fortunately, the attack is not

a severe one, and does not check the valuable work of the Cochineal Insect to any great extent. But the point is that, in so far as *Cryptolaemus* makes this attack, it must be classed as an *injurious insect*; whereas, in attacking the Mealy-bugs of citrus trees, it must be classed as a *beneficial insect*.

The contrast is best illustrated by means of a Table, as follows:—

TABLE.

Organism	Relationship to Man.			
	Type	Example	Type	Example
1. Plant	Beneficial	Orange and Lemon Trees	Injurious	Prickly Pear (in Australia).
2. Insect attacking plant	Injurious	Mealy-bugs ( <i>Dactylopius</i> spp.)	Beneficial	Cochineal Insect ( <i>Dactylopius tomentosus</i> ).
3. Insect predatory or parasitic on 2.	Beneficial	Ladybird Beetle ( <i>Cryptolaemus montrouzieri</i> )	Injurious	Ladybird Beetle ( <i>Cryptolaemus montrouzieri</i> ).
4. Secondary parasite (hyperparasite) on 3.	Injurious	Species of <i>Braconidae</i> , etc.	Beneficial	Species of <i>Braconidae</i> , etc.

I think the above table shows very clearly the idea that I am intending to convey, viz., that *the problem of the Biological Control of Noxious Weeds is the inverse of the problem of the Biological Control of Insect Pests*. In the latter case, we seek to protect the plant by the destruction or control of its insect enemies, utilising their predators or parasites for this purpose. In the former case, we seek to destroy the plant, by the utilisation of its insect enemies, after having first eliminated their predators or parasites from the problem.

It being now generally admitted that Biological Control of Insect Pests is sound in theory, it follows logically that the inverse problem is also sound in theory; for the two problems do not differ *fundamentally*, but only differ in their orientation to the viewpoint of mankind.

It having also been proved, by many striking examples, that Biological Control of Insect Pests may be made to yield valuable results, and may achieve these at a cost which is trifling compared with other known methods, we have now to

examine the problem as to what conditions are required in order that the inverse problem of Biological Control of Noxious Weeds may also be made to yield valuable results.

The first point which will strike everybody is this:—

When an injurious insect pest gains admittance into a new country, it becomes capable of, and frequently inflicts, far greater damage than it did in its country of origin. This known fact, transferred to the inverse problem of the control of noxious weeds, may be rendered in two ways:—

(1) If an insect known to be injurious to a given noxious weed is introduced into a new country, it may be expected to do far greater damage to that weed than it did in its country of origin.

(2) On the other hand, if this same insect can also attack any other plant besides the given noxious weed, and such other plant is of economic value, equally serious damage may be anticipated to that plant; and the gain to the country in the control of the weed may be more than offset in the loss to the industry in which the other plant is of importance.

These facts being admitted, we have now to inquire into the safeguards necessary to ensure (a) *the maximum attack upon the weed itself*, and (b) *the elimination of all risks to plants of economic value*.

With respect to (a), it is only necessary to say that the obvious method of procedure is to introduce only strong and healthy strains of the insect, preferably from regions not differing too markedly in climate from that of the country of introduction, and to make sure that all parasites or other enemies of the insect in question are eliminated from each consignment before it is forwarded.

With respect to (b), we have to consider first of all the *theoretical risk* and then tackle the problem of *reducing that risk to a practical minimum*.

#### THE THEORETICAL RISK.

Theoretically, the risk taken in introducing any given insect to attack a given noxious weed is more or less closely related both to the *degree of specialisation* of the insect and to the *botanical position* of the weed in question. It is well known that the great majority of species of plant-feeding insects are more or less restricted in their diet. The more highly specialised the group of insects concerned, the more marked is this restriction. This is not to be wondered at,

when we consider for how many millions of years the higher insects have been evolving, and more especially when we recall that the fossil record indicates that they reached a stage of practical stability in their reactions to food and other stimuli two or three million years ago, long before Man came on the scene. We have, then, first of all to consider the *type of insect* that we propose to introduce, and secondly, the *type of weed* which we desire to attack.

Insects have now been studied long enough for an immense mass of information to have been gathered together and published about a very large number of them. This is particularly true about the insects of Europe and North America, the two countries from which we may expect to draw most of our supplies of insects for control of noxious weeds. It follows that we shall be able to classify our insect into one of the three following groups:—

- (1) Insects which have been recorded as attacking plants of economic value.
- (2) Insects only recorded as attacking the genus to which the noxious weed belongs, or allies of it, having no economic value.
- (3) Insects not well enough known or sufficiently studied to enable them to be placed either in (1) or (2).

Generally speaking, if an insect falls into group (1), it should not be considered for noxious weed work. Insects of group (3) should be followed up by fuller study in their countries of origin, until they can be placed either under (1) or (2). Insects of group (2) are suitable subjects for further research, especially those in which the records run back far into the past without showing anything dangerous to economic plants in their recorded habits.

The next point to consider is the botanical position of the noxious weed under consideration. Does it stand far apart from any of the groups which contain our most valuable economic plants, or does it, on the other hand, belong to such a group? It must be obvious that the risks of the work are reduced to a minimum in such cases as Prickly Pear or St. John's Wort, where the weed is highly specialised, and stands far apart from any group of economic plants. In such a case, it is reasonable to suppose that a series of careful tests carried out upon any insect, with a view to discovering its feeding range, would indicate clearly that certain species were entirely, or almost, confined to the weed in question. On



the other hand, in such cases as Blackberry or Hoary Cress, where the weed in question stands botanically right in the middle of a group of the highest economic value, the risks must be regarded as very great, and the likelihood of discovering any single species of insect that would be confined to such a food-plant is exceedingly small.

There is also another point which must not be lost sight of, viz., that, even though a given noxious weed may belong to a group of economic value, it may be so specialised in the morphology of one or more of its parts that there is still a good chance of finding a specialised insect which would attack that part, without any risk to related plants in which that same part is quite differently specialised. This can be well illustrated by two examples:—

(1) Piri-piri (*Acæna sanguisorbæ*) belongs to a genus closely related to Strawberry (*Fragaria* spp.). The leaves of the two genera are closely similar, but the fruit are specialised in two very different directions. It might therefore be expected that a leaf-feeding enemy of *Acæna* would attack the leaves of strawberries also; and such is actually the case with the Australian beetle *Haltica pagana*, which only feeds in nature on *Acæna*. In attempting, therefore, to control piri-piri in New Zealand, a search should be made for a fruit- or seed-feeding species. (See p. 76.)

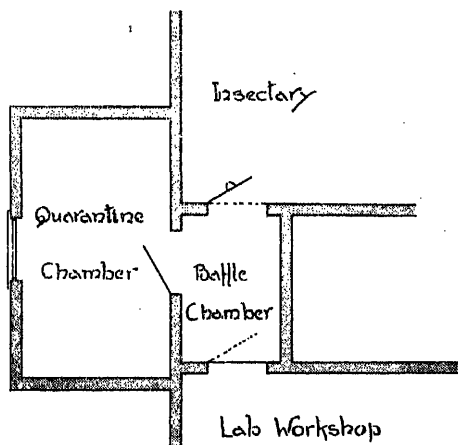
(2) Gorse (*Ulex europæus*) is a member of the Natural Order Leguminosæ, which includes also a large number of our most valuable vegetables and fodder crops. It is, however, specialised in being a prickly shrub and in its peculiar type of seed-pod. It is not to be expected that an insect that feeds naturally inside the seed-pod of gorse would also attack the pods of peas, beans, clovers, or lucerne. Tests carried out on the little gorse weevil, *Apion ulicis*, show that it cannot even accustom itself to the pods of the allied genus Broom (*Cytisus*). It is therefore a safe insect to work with.

To sum up, then, the theoretical risk is least when the plant to be controlled is unrelated to any group of economic plants, or, if related, is distinguished from them by the possession of some morphological specialisation; it is also reduced in proportion to the degree of specialisation of the insect intended to be used.

#### PRACTICAL METHODS OF ELIMINATING RISK.

The practical methods of eliminating risk in Noxious Weeds Control work, or of reducing it, at any rate, to a mini-

mum low enough to justify the continuance of the work, are by now fairly well understood, as the result of the experience of the past few years. The first consideration is so to arrange the experiments in the country of introduction that they are *under quarantine control conditions*. This is ensured by the construction of *quarantine insectaries* conforming to the requirements of the Commonwealth Department of Public Health as quarantine areas. Plates XV., XVI., XVII., and XVIII. give a good general idea of such insectaries. They have to be entirely insect-proof, protected from damage from the outside, and provided with a properly constructed *baffle-chamber* with interlocking doors, as shown in Text Figure.



Diagrammatic Plan to show arrangement of Baffle Chamber and Insectary at the Cawthron Institute, Nelson, New Zealand. The Insectary can only be entered from the Laboratory Workshop through the Baffle Chamber, the two opposite doors interlocking so that, when one is opened, the other is automatically shut. The insect trap is indicated by the small cone on the insectary side of the inner door. The Quarantine Chamber or Store is also entered only from the Baffle Chamber, by means of a side door.

Only the workers actually engaged upon the research should be allowed to enter them when work is in progress, and such workers have to be very carefully instructed in the use of the baffle-chamber, and in ensuring that they do not carry insects in or out of it on their clothing.

The second point is to ensure that only such insects are allowed into the country of introduction as can be definitely classified in group (2) on p. 59. For this purpose, a worker has to be employed in the country of origin, to determine, by means of a series of *starvation tests*, what the feeding range of the given insect may be. A list is drawn up, including

all the principal economic plants which grow in that part of the country of origin infested by the weed. The insect is given the choice of either feeding on one of these, or of starving. If it prefers to starve to death, it is a reasonable inference that it will not eat this same plant when supplies of its natural food are also available. In order to make these tests as full as possible, the insect is tested in this manner at various stages of its life-history from the newly-hatched larva to the adult. Each test is controlled by dividing a batch of insects into two equal parts, say twenty larvæ in each batch; one batch is then placed in a cage on the economic plant to be tested, while the other batch is placed in a similar cage on the normal food-plant. If the latter batch feeds freely while the former starves, the test is regarded as valid.

Assuming that the insect under observation in its country of origin successfully passes all its tests, it is then necessary for the scientist in charge of the work to draw up a full account of its known life-history, giving information on the specific points of its capacity to damage the weed in question, its inability to do harm to other plants, and the proposed line of work to be carried on in the country of introduction. This document is sent in to the Department of Public Health with the application for a *quarantine permit*. If such a permit is granted, the insect has then to be received into the quarantine insectary,\* and a further series of tests has to be carried out there. These tests consist of a repetition of the starvation tests under the new conditions of climate, etc., in the country of introduction, together with a certain number of oviposition tests designed to determine the oviposition responses of the insect. (Sometimes an insect will lay eggs on a plant on which the larvæ cannot feed; or it may happen that the larvæ will feed on a particular plant, but the insect may refuse to oviposit on it. In either case, an accurate knowledge of the oviposition responses of the given insect is highly desirable.) The starvation tests are also increased to include native plants of economic value, not available in the country of origin, e.g., in the case of Australia, eucalypts and wattles.

*Permission to test any given insect in the field is only sought in the case of such insects as have undergone all the above stringent tests with negative results. This means, inevitably, that the work to be done will be long and arduous;*

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\*I have purposely omitted from this account a discussion of the important problems of the carriage of live insects through the Tropics and the subsequent difficulties of acclimatisation in the new country.—R.J.T.

but it undoubtedly reduces the risks of the work to a minimum, and its results, as shown in the case of the Prickly Pear work in Queensland, are such as to ensure public confidence in the method.

In the case of an insect which successfully passes all its tests and for which an open permit for liberation in Australia is granted, there still remains the difficult task of devising methods whereby it can be reared in sufficient quantities and distributed rapidly enough in the infested districts to ensure the destruction of the weed. This is a separate problem, which I do not propose to enter upon here.

I trust that I have shown you, in this first section of my lecture, that Biological Control of Noxious Weeds is sound theoretically, and that the practical safeguards devised are such as to protect the country in which the work is to be carried out. I now propose to go on to the other sections of my lecture, in which the four main experiments in Noxious Weeds Control work to date are studied in detail.

## II. EARLY HISTORY OF BIOLOGICAL CONTROL OF NOXIOUS WEEDS.

The great credit of inaugurating work on the biological control of Noxious Weeds must be given to that extremely progressive body, the Hawaiian Sugar Planters' Association, and their very capable entomologists. It is just about thirty years ago that the first experiment in this direction was undertaken by this body. The plant *Lantana camara*, originally introduced about the year 1860 as an ornamental shrub, soon began to take possession of large areas of land in the various islands of the Hawaiian group, just as it has done over large tracts of similar land in the warmer portions of Eastern Australia. The well-known entomologist Koebele, while collecting in Mexico in 1898, noticed that the seeds of this plant in its native state were damaged by insects which bred in them. This suggested to him the idea that the profuse seeding of the plant might be checked, or even completely prevented, if these insects could be firmly established on the weed lantana in the Hawaiian Islands. Four years later, his idea having been officially approved, he again visited Mexico, and this time made a thorough study of all the insects that feed on lantana. More than twenty different species of these were shipped back to the Chief Entomologist, Perkins, in Honolulu, and eight of these were soon successfully established on the Island of Oahu, of which Honolulu

is the capital. Of these the most important were the species that prevent the seeding of the plant. The larvæ of an Agromyzid fly, *Agromyza lantanae*, proved to be the most effective of these; it attacks the berries before they are mature, and causes them to shrivel up, destroying the seeds within them. The rapid spread of this insect in all the drier areas of the Hawaiian Islands was most marked. Other valuable introductions were the Tortricid Moth, *Crocidosema lantana*, and the two Hairstreak Butterflies (family Lycænidae), *Thecla ecklon* and *T. bazochii*. The larvæ of the first-named are stem-borers, attacking chiefly the tender flowering stems and thus destroying both flowers and fruit. The Butterfly larvæ feed chiefly on the flowers, and are therefore also of great value in preventing the formation of the fruit.

The result of these introductions was a very marked decrease in the amount of infestation by lantana in the drier parts of the islands. With the aid of some judicious mechanical clearing, these parts have now been rendered safe for all time from being overrun by this dangerous weed. In the wetter portions of the island, especially on Hawaii itself, where there are great tracts of lava particularly suitable to the growth of lantana, the attempt at control has not been so successful; but, from the economic point of view, these lands are not of much importance.

I want now to emphasise to you a very important point, viz., that, in this first experiment with biological control of noxious weeds, a very grave risk was taken, viz., that some of the introduced insects might have proved capable of attacking valuable economic plants, and might have themselves become worse pests than the lantana. That this did not happen might be said to have been more by good luck than good management; for no stringent tests were applied beforehand to discover fully the habits of the introduced insects. Luck was on the side of the experimenters! Even so, one of the introduced insects, *Thecla ecklon*, occasionally selects the fruit of the egg-plant as its food in the larval state, though it has not become a serious pest on that plant. This example only serves to show, I think, what a "near thing" it was for this first experiment in noxious weeds control. Had any single one of these insects turned out to be a major pest on any important economic plant, such as sugar-cane or pineapple, I think it is safe to say that entomology in the Hawaiian Islands might have received its deathblow.

Needless to say, though the experiment on lantana control was to a large extent successful, there was no lack of

critics ready to point out the danger that had been run, and for a long time afterwards the policy of the Hawaiian experimenters was rather to "lie low and say nuffin'," being content with their success, than to attempt to draw any general conclusions from the work they had accomplished. Later on, however, the work was taken up again by a new generation of Hawaiian entomologists, and at the present time attempts are being made at the biological control of three important noxious weeds in these islands, viz., Nut-Grass (*Cyperus rotundatus*), Pamakani (*Eupatorium glandulosum*), and Gorse or Furze (*Ulex europæus*). The last of these is, as you know, a serious pest in New Zealand and Tasmania.

### III. BIOLOGICAL CONTROL OF PRICKLY PEAR IN AUSTRALIA.

We must now turn our attention to the second experiment in biological control of Noxious Weeds, viz., the attempt to control Prickly Pear (*Opuntia inermis*) in Australia. I venture to say that, whatever may be its ultimate result (and I, for one, have little doubt of its success), this great undertaking will rank for all time as one of the most instructive and interesting pieces of biological research ever undertaken by mankind. There will always be, no doubt, many individuals who will refuse to allow that it is a success until the last clump of prickly pear has gone by the board. But, looking at the matter from a broader view, I think we may claim already for this work, firstly a complete success on the scientific side, in so far as it has firmly established the value of the principle of biological control of noxious weeds, and secondly already a considerable economic success, in view of the effectiveness of the safeguards established, and the large measure of economic control of the weed already attained.

Various species of Prickly Pear (*Opuntia*) were introduced into Eastern Australia many years ago as botanical curiosities. In addition to the interest created by their curious habit of growth, the plants themselves are used in several parts of the world for making dense, impenetrable hedges, and their fleshy, slightly acid fruit is esteemed as a delicacy. As many birds share in this liking for the fruit, and as the plant can stand any amount of drought, and every little piece of it, if thrown away haphazardly, is able to take root and become a separate plant, it is not to be wondered at that, in the course of time, this plant became the pest weed, *par excellence*, of the warmer parts of Eastern Australia.

When it became known that some 60,000,000 acres of land in Queensland and northern New South Wales had been overrun by this plant, and that it was increasing at a rate of more than 1,000,000 acres a year, public opinion soon became translated into legislative action; for this was, surely, nothing less than a national calamity which threatened the future existence of two States. As the story of the inauguration of the Prickly Pear Board and the results of its ten years of fruitful work has been very fully told in the publications, firstly, of the Commonwealth Institute of Science and Industry, and, later, of the Commonwealth Council of Scientific and Industrial Research, it is not necessary here to refer to more than its bare outlines.

The Prickly Pear Board was founded late in 1919, and held its first meeting in 1920. It consisted of three members, one representing the Commonwealth of Australia, one the Government of Queensland, and one the Government of New South Wales. The Commonwealth representative was Mr. Gerald Lightfoot, M.A. (now Secretary of the Commonwealth Council of Scientific and Industrial Research), who is at the present time still a member of the Board. The State representatives were the Under Secretaries for the Department of Public Lands in Queensland and Agriculture in New South Wales. The Board was financed by an annual grant of £8,000, half of which was contributed by the Commonwealth, and one quarter by each of the States concerned. From the beginning of 1926, this amount was increased to £12,000 in the same proportional contributions.

In October, 1926, the Board was strengthened by the addition of a fourth member, Professor E. J. Goddard, of the University of Queensland.

The main factors in the adoption of the principle of biological control may be briefly summarised as follows:—

(1) *Mechanical control* (i.e., by cutting out the plant with hand labour or by the agency of various mechanical devices) has been found to be slow, costly, and arduous.

(2) *Chemical control*, though valuable in the case of land above a certain value per acre, is too expensive to offer a general solution of so immense a problem. The land of agricultural value to which chemical control could be profitably applied is only a small portion of the total huge area of infestation, and would be continually reinfested from the untreated portions, as long as these latter were neglected. Dr. Jean White's earlier work on the use of arsenic acid and

arsenic trichloride for the control of this pest was of great value in indicating the cheapest and most effective chemical methods that could be used. These methods cannot be applied to the major problem, as they are too expensive; but they are of great value in assisting the work of biological control.

(3) *Utilisation of the pear on a large scale* has been shown to be impracticable. Even if the pear could be turned into cattle fodder, the annual increase in Australia is far more than sufficient to feed all the cattle we possess!

The one remaining hope was the application of the principle of biological control. Here the Board had the guidance of Professor T. Harvey Johnston, who, with Mr. Henry Tryon, had already formed a Travelling Commission for the Queensland Government, and had submitted a report embodying the results of two years of travel in many of those countries in which the genus *Opuntia* occurs. The main point that emerged from this preliminary work was that most of the large number of species of insects that naturally fed on *Opuntia* were not known to attack other plants, and therefore they might reasonably be experimented with in Australia, *provided proper safeguards were adopted*.

Professor Harvey Johnston was appointed Scientific Controller of the Prickly Pear work as from June, 1920, and held that post until his resignation in February, 1923. This post was then discontinued, and an Officer-in-charge was appointed to carry on the work. The first Officer-in-charge was Mr. J. C. Hamlin, who held office only for a short time, and was succeeded by Mr. W. B. Alexander, who was succeeded in 1926 by the present occupier of the post, Mr. Alan P. Dodd.

The work on biological control of Prickly Pear may be divided up into the following main sections:—

(1) *Collecting the insects in the field*:—For this purpose, an intensive survey of all the countries in which *Opuntia* occurs as a native plant has now been carried out. These countries range from Texas and Florida in the North to Argentina in the South.

(2) *Testing of the insects before shipment to Australia*:—A central testing station was established at Uvalde, Texas, where each species of insect was reared in cages, freed from its native parasites, and then tested out on a large selection of economic plants. Insects which successfully passed these tests were then shipped to Australia.



(3) *Shipping the insects to Australia*:—This important and difficult operation was overcome by packing the insects in specially designed Wardian cases, carried as deck cargo, and for the most part shipped direct from San Francisco to Sydney. Insects from Southern America were treated similarly, but shipped from Panama.

(4) *Work at the Central Laboratory*:—This laboratory (Plate XIII.) was established at Sherwood, a suburb of Brisbane, Queensland. The introduced insects are received at this station, and are there bred in large numbers for distribution to the field stations.

(5) *Work at the field stations*:—Three field stations were established in the main areas of infestation, viz., one at Westwood, near Rockhampton, in Queensland, one at Chinchilla, Queensland, and one at Gravesend, in north-western New South Wales. Later on, the Westwood field station was discontinued, and a new one opened at Gogango, a more suitable locality. In these stations, the introduced insects are reared in sufficient numbers to allow for liberal distribution in the open.

Let us now look at the results of this work to date.

Five groups of *Opuntia*-feeding insects have been acclimatised in Australia, after successfully passing the tests on economic plants. Arranged in their order of importance from the economic viewpoint, these are as follows:—

(1) *Tunnelling caterpillars* (larvæ of Lepidoptera of the family Pyraustidæ):—The first of these to be studied and liberated were two species of the genus *Melitara*, one of which (*M. junctolineella*) readily attacks the pest pear (*O. inermis*) while the other (*M. prodenialis*) only attacks *O. stricta*. But by far the most important of all the pear-controlling insects is the later importation from the Argentine, *Cactoblastus cactorum*, introduced in 1925. This voracious feeder attacks *O. inermis*, *O. stricta*, and *O. aurantiaca*, causing destruction of its host-plant out of all proportion to its numbers, owing to its association with a soft-rot bacillus, which causes the rotting away and destruction of the tissues. The only event which, apparently, can check the complete triumph of this remarkable insect enemy of Prickly Pear would be its gradual secondary control by parasitism from native Hymenoptera or Diptera. To date, this has only occurred to a very minor degree, not sufficiently marked to produce any decided effect on its onslaught.

(2) *Cochineal Insects* (Hemiptera-Homoptera of the family Coccidæ):—These insects are mealy-bugs of the genus *Dactylopius*. The first species introduced was found to attack only the tree-pear, *O. monacantha*, which it very soon almost completely eradicated. Later, another species, *D. tomentosus*, was introduced to feed on *O. inermis*. Three strains of this insect are now at work in Australia, having been very widely distributed. They do splendid work in destroying young seedlings, in killing off old plants, and in attacking pear infestations in forest country, but do not work as rapidly as *Cactoblastus*.

(3) *Red Spider*:—The Prickly Pear Red Spider, *Tetranychus opuntiae*, is, of course, not an insect, but an Arachnid of the group Acarina. It was introduced from Texas in 1924. These little red mites feed on the surface of the pear, and cause great damage, followed by collapse of the plant and often by its death. They are particularly valuable in attacking dense infestations of *O. inermis*.

(4) *Plant-sucking Bugs* (Hemiptera-Heteroptera of the family Coreidæ):—Four species of the large bugs of the genus *Chelinidea* have been introduced from North and Central America. One of these, *C. tabulata*, has increased very greatly, and is doing excellent work in attacking the pest pear and weakening it by piercing and sucking the sap.

(5) *Tunnelling Beetle Grubs* (Coleoptera, family Cerambycidæ):—Several species of the genus *Moneilema* have been introduced, but only one, *M. ulkei*, has been established in the field. The adult longicorns of this genus are wingless.

A sixth type of insect attacking *Opuntia* is a group of fruit-feeding species. Of these, the most promising appeared to be *Asphondylia opuntiae*, one of the Cecidomyiidæ (Order Diptera). This insect, however, has proved an exception to the general rule in *Opuntia*-feeding insects, as exhaustive tests have shown that the larvæ may damage certain other fruits of economic importance. Under these circumstances, the attempt to utilise it has been abandoned.

We may summarise the work of the Prickly Pear Board on the biological control of Prickly Pear by saying that, to date, it has progressed probably even better than its most ardent supporters hoped. To-day it stands as the one scientifically founded method of attempting the control of this serious pest with an expenditure that may be considered to lie within reasonable limits of national finance. While it

would be foolish to attempt to prophesy what the future has in store, bearing in mind the possibilities still existing of a check occurring in the work of any given insect, either through parasitism by native insects, attacks by native predators, or through a slow change in the insect organism itself, whereby it may become more normally accommodated to its host-plant under its new environment, I think it is not too much to say that the prospects of a satisfactory ultimate controlling stage being reached are extremely good. We have to remember that the result aimed at will be attained, even without complete eradication of the weed, provided that the introduced insects can reduce its spread to proportions that may be considered negligible from an economic standpoint, and can succeed in preventing it from ever again obtaining the upper hand in Australia.

#### IV. BIOLOGICAL CONTROL OF NOXIOUS WEEDS IN NEW ZEALAND.

As I have already indicated to you, ten years ago the general principles of biological control of an insect pest by its natural enemies were by no means generally admitted even amongst entomologists, while the number of such who would at that time have supported biological control of noxious weeds was very small indeed. My first acquaintance with the subject of this lecture was in 1920, when I paid my first visit to the Hawaiian Islands. While that visit showed me to a considerable extent the success that had attended the attempt to control *lantana* by this means, yet the little that one could learn about the technique of the experiment did not tend to influence one in favour of repeating it. It was thus with quite an open mind that I paid my first visit to the Central Laboratory of the Prickly Pear Board at Sherwood, in 1924, when I was shown the work in progress at that time through the kindness of Mr. W. B. Alexander. Here I found a much more thorough and scientific piece of work being carried out, and was able to gather my first impressions of the complexities of the problem. The result of this was to send me back to Nelson, New Zealand (where I was then working as Chief of the Biological Department of the Cawthron Institute of Scientific Research), in a frame of mind bent on examining the possibilities of applying the new method to the serious problem of New Zealand Noxious Weeds. As the most important of these weeds is Blackberry (*Rubus fruticosus*), an extremely close ally of the two valuable fruits

Raspberry and Loganberry, and also a fairly close ally of Roses and a host of valuable orchard trees, I am sure you can imagine the state of mind produced by having to face this problem, and having to decide once and for all whether to drop the method as being too dangerous, or to go on with it and risk the danger.

I hope you will all approve of the decision which I reached, at a time (let me emphasise this) when not a single other scientist in New Zealand was prepared to give me the slightest support in it,\* and when I met with severe and at times unreasoning opposition from those who ought at any rate to have listened impartially before prejudging the position. My decision was to give the method a thorough trial, but to increase the safeguards to the utmost, in proportion as the problem of control of such weeds as blackberry appeared to carry with it risks of a graver nature than was the case with Prickly Pear.

Fortunately the Cawthron Institute is blessed with a Director and a Board of Trustees who are broad-minded men, and who listened to the proposal put before them with impartial minds. The outcome of it was that I was given permission, in 1926, to visit Europe and America in order to discuss this and other matters with leading entomologists, and to see what could be done to set going a practical scheme.

Before leaving New Zealand, I had drawn up, in consultation with the officers of the Department of Agriculture, a scheme of regulations in the form of safeguards for the control of the work (Tillyard, 1927a, p. 1). These regulations admittedly made the proposed research very difficult, but they were absolutely necessary in view of the obvious risks entailed. With this set of regulations agreed to, I then set out to win over my old friend and counsellor, Dr. L. O. Howard, at that time Chief of the Federal Bureau of Entomology in Washington, and so far succeeded in my endeavour that he gave me cautious support and at the same time wrote a letter to Dr. G. A. K. Marshall, Director of the Imperial Bureau of Entomology in London, commending my plan for his consideration. In England I gained the support of Dr. A. D. Imms, Chief Entomologist at Rothamsted Experimental Station, and obtained the consent of Sir John Russell to the carrying on of some experimental work along the proposed

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\*As I write this (September, 1929), I have before me the report of a speech by a member of the Legislative Council of New Zealand (Hon. G. M. Thompson) still attacking the Cawthron Institute at this late stage for undertaking this work!—R.J.T.

lines at Rothamsted, under Dr. Imms's supervision. Dr. Marshall also very generously gave me official support, though he was not personally in favour of the work.

With all this accomplished, I was then able to approach the Empire Marketing Board with a proposal for a grant in aid of this work. Again I was fortunate in meeting with men who had open minds on the subject, and could clearly see the Imperial aspect of the work. The result was that an offer was made by the Board to the Cawthron Trustees, in the form of a grant of £2,000 for the necessary buildings, and £2,000 a year for five years for the actual carrying out of the research, on condition that the New Zealand Government and the Cawthron Trustees together also expended an equivalent annual sum. This offer was accepted, and the work was begun in 1927. A committee was set up by the newly formed Department of Scientific and Industrial Research in Wellington to control the work, of which I was put in charge, with Mr. A. L. Tonnoir as Field Entomologist working under me at the Cawthron Institute, and Mr. W. M. Davies as Entomologist working under Dr. A. D. Imms at Rothamsted.

Building being reasonably cheap in Nelson, the grant of £2,000 for that purpose was found to be sufficient to erect a small biological control station with attached insectary (Plates XIV. and XV.). The station contains two research rooms, a dark-room, a large general laboratory, a cool-store, and a small workshop. It was connected directly with the large quarantine insectary, about fifty feet square, by means of a baffle-chamber (see Text Figure), the doors of which were interlocked in such a manner that neither of them could be opened until the other was firmly shut. The baffle-chamber also communicated with a quarantine store-room at the side. These buildings were completed in 1927, and were officially opened by the Right Hon. L. S. Amery, P.C., Chairman of the Empire Marketing Board, on the occasion of his visit to Nelson. The Noxious Weeds work was carried on, under my direction, by Mr. A. L. Tonnoir as Field Entomologist, with the assistance of two cadets, Mr. R. Mayson and Mr. E. Newman.

The weeds chosen for research at the start were black-berry, ragwort, and gorse. Later on, an investigation into piri-piri or bidi-bidi (*Acæna sanguisorbæ*) was begun as well. The first selection of likely insects was made by myself during my visit to Europe in 1926, and resulted in the work being concentrated upon the following species:—

For Blackberry:—*Thyatira batis*, *Coræbus rubi*, *Agrilus ruficollis*, and *Bembecia marginata*.

For Ragwort:—*Tyria jacobææ* and *Homæosoma vagella*.

For Gorse:—*Apion ulicis*.

Blackberry (*Rubus fruticosus*) is generally considered to be the worst pest weed in New Zealand; it is also a very serious weed in many parts of Australia where the rainfall is high enough to favour its spread. The total acreage under blackberry in New Zealand has never been computed; but it is very evident that the weed has a great hold on the country, and is spreading at an alarming rate. One of the chief agents in this spread is the introduced Blackbird, which feeds greedily upon the ripe fruit, passing the seeds out in its droppings. There is a well-known saying on the west coast of the South Island that in that district they have only one blackberry bush, but it is two hundred miles long!

The attempt to control blackberry is a most difficult one, from whatever angle it may be viewed. Here is a most vigorous weed, which not only seeds freely, but sends up shoots readily from its underground stems and responds as readily to hacking and cutting as a fruit-tree does to careful pruning. Attempts to destroy it with chemicals have met with some success, but are very expensive owing to the rampant growth of the weed and its ability to seize and hold the most inaccessible places. From the point of view of biological control, it is about as unfavourably placed botanically as it could possibly be, as the genus to which it belongs (*Rubus*) also includes the very valuable fruits Raspberry and Loganberry, and lies in the very centre of that great complex of related forms, the Natural Order Rosaceæ, in which are included most of our valuable deciduous fruit trees, as well as the Queen of Flowers, the Rose, and a host of other garden flowers and ornamental trees and shrubs. It seemed from the outset that there would only be a small chance of discovering an insect which could distinguish clearly between blackberry and its near allies. The application of the requisite tests brought about the speedy downfall of the first insect studied, *Thyatira batis*, which was found to feed readily on raspberry and also failed to do sufficient damage to blackberry to make it worth while continuing the tests. The most promising insect appears to be the Buprestid beetle *Coræbus rubi*, known to attack the roots and crown of blackberry in the south of France, and only recorded otherwise on *Rosa indica*, used as a stock for ornamental roses around Grasse.

This stock not being used in New Zealand to any extent, a good case was presented for continuing with this beetle. At the present time, an unexpected difficulty has presented itself, after the initial problem of the successful transport of the delicate beetle grubs to New Zealand had been overcome, in that the New Zealand bred females of the beetle, though paired and fertilised by the males, have apparently not yet produced any fertile eggs. The factor inhibiting fertility is at present not understood, and the research cannot move forward until this problem is solved or some other insect is discovered more promising than *Coræbus*.

A similar difficulty appears to have intervened in the case of what appeared at the beginning to be a most promising insect for controlling gorse or furze (*Ulex europæus*). This weed, originally introduced as a hedge-plant into New Zealand, is a very vigorous seed-producer, and has spread over immense areas of hilly land in the Dominion, while it is also a problem in parts of Tasmania. In England and France the seeding is often controlled to a very great extent by the attacks of the larvæ of a small weevil, *Apion ulicis*, which inserts its eggs into the young pod, where the larvæ live and entirely destroy the seed. Large consignments of this beetle have been imported into New Zealand, and to a certain extent acclimatised; but this same problem of infertility again presents itself as a barrier, and the cause of it has not yet been discovered. Added to this is another barrier to success, viz., that in New Zealand the gorse is predominantly a winter-flowering plant, and the introduced insects are unable to synchronise their life-cycle with the flowering period of the plant. Thus we see how, even in a case where the insect is a safe one to work with (for this little weevil will feed on nothing but gorse), unforeseen difficulties may arise which prevent the fulfilment of one's legitimate hopes. It seems fairly clear by now that some other insect, such as *Tortrix ulicitana*, will have to be taken in hand in the effort to control gorse.

The best measure of success in these difficult New Zealand problems has been met with in the work on control of ragwort (*Senecio jacobææ*). Here the most promising insect appeared to be *Tyria jacobææ*, the well-known Cinnabar Moth, which feeds on ragwort in England, and frequently almost entirely destroys it over large areas. The first consignment of pupæ of this moth was brought back by me to New Zealand in 1927, and many more consignments have been supplied from Rothamsted since. Very full tests have

been made on a long series of native and economic plants with this insect, particular attention being paid to potato owing to there being a fallacious record of the larva having been found eating this plant. The moth, however, successfully passed all these stringent tests, and is undoubtedly a safe insect to try out in the field. My last official act before leaving Nelson to take up my present position, after receiving a permit from the New Zealand Government to place this insect out in the open on an experimental plot near the new laboratory in Nelson, was to put the caterpillars out on the ragwort plants growing there. Since that time, my successor, Dr. D. Miller, has carried this work forward to the stage when large numbers of the insects are available for distribution in the field. With the aid of the field staff of the Department of Agriculture, some half-million eggs of *Tyria* have been distributed in selected areas of infested country around Te Puke, Hamilton, Stratford, and Invercargill, and their effect on the weed will be watched with great interest. The principal danger appears to lie in the possible checking of the work of the moth, either through attacks from native parasites of the closely allied Magpie Moth, *Nyctemera annulata*, or in the destruction of large numbers of the caterpillars in the field by a polyhedral wilt disease, such as occurs in the rearing-cages when too great a concentration of the larvæ is allowed to take place.

I have given these New Zealand researches at some length, because they help to dispel the feeling, which one cannot help getting from a study of the splendid results with Prickly Pear, that biological control of noxious weeds is "fairly plain sailing." This is emphatically not the case, even in so favourable a case as that of prickly pear. The factors that may make it appear so are, in that case, two only, viz., the isolated position of the weed botanically, which made it appear *a priori* as very unlikely that any *Opuntia*-feeding insects would attack other species of plants outside of the Cactaceæ, and the sub-tropical climate, which greatly facilitated the work of introduction and acclimatisation. In the case of the New Zealand weeds, neither of these factors operates. The climate being temperate, but the country in the Southern Hemisphere, a difference of six months has to be overcome in the life-cycles of the introduced insects; possibly this may be one of the major factors in the remarkable cases of infertility already mentioned. Two of the weeds studied occupy unfavourable botanical positions: the case of blackberry has been already specifically outlined, and gorse



is a member of the Natural Order Leguminosæ which contains many valuable economic plants. Ragwort is a member of a genus, *Senecio*, which is widely represented by native herbs and shrubs in New Zealand. Of the three, the most promising case is that of ragwort, and, as might have been anticipated, the greatest progress has been made with it. The presence of native species of *Senecio* in New Zealand is not in itself of great moment, since none of them is of economic value, though many are very beautiful shrubs; but it is of importance indirectly, as this genus is the food-plant of the common moth *Nyctemera annulata*, a close ally of *Tyria*, and it is the parasites of this moth which may become the most probable factor in limiting the success of the work of *Tyria* in New Zealand in the future.

*Acæna sanguisorbæ*, the native piri-piri or bidi-bidi, causes serious losses in New Zealand through its burrs adhering to the wool of sheep. This weed is also native to Australia, and is controlled in many districts by a Chrysomelid beetle, *Haltica pagana*, which entirely destroys it. This little beetle, however, is known also to have a taste for strawberries, a fruit which is, botanically, very closely allied to the genus *Acæna*. This fact rules *Haltica* out, and Dr. Miller is now searching elsewhere for an insect which will attack *Acæna* without showing a partiality for strawberries. In 1927, I initiated inquiries in Chile and the Argentine about natural enemies of the genus *Acæna*, which has its headquarters in those regions. Through the kindness of Dr. L. O. Howard, I got into touch with Brother Claude Joseph of Temuco, Chile, who recommended a trial of the native Sawfly *Antholcus fractinervis* (Order Hymenoptera, family Tenthredinidæ). This insect completely destroys the flower-heads of a number of native species of *Acæna*. Two small consignments of this insect in the pupal stage were forwarded to New Zealand; but unfortunately, owing to unsuitable packing, no emergences took place there. This experiment will be repeated by Dr. Miller on a larger scale.

When arrangements were made with the Director of the Imperial Bureau of Entomology, Dr. G. A. K. Marshall, for an Australian worker on Noxious Weeds Research to carry on his work at Farnham House Laboratory, Farnham Royal, Bucks., the work then being done on behalf of New Zealand at Rothamsted by Mr. Newton, the successor to Mr. W. M. Davies, was also transferred to Farnham Royal. The present arrangement is that New Zealand makes an annual grant of £1,000 to the Imperial Bureau for the carrying out of the

work, which is now in the hands of Mr. Watt, an officer of the Bureau. Mr. Tonnoir severed his connection with the Nelson end of the work this month (September, 1929) on taking up his new appointment on the staff of the Division of Economic Entomology at Canberra, and a rearrangement of the work in Nelson has consequently been made.

To sum up the position as regards the New Zealand work:—The original grant from the Empire Marketing Board was made for five years, it being recognised that at least that period would be needed to show results. A little more than half of this period has now passed. To date, only one insect has become successfully acclimatised and passed all the severe tests imposed upon it, viz., the Cinnabar Moth, *Tyria jacobææ*. The present summer should go far towards indicating the value of this insect against ragwort in the field. The researches with two other promising insects, *Coræbus rubi* on blackberry and *Apion ulicis* on gorse, are held up through the development of infertility in the females after acclimatisation in New Zealand. Much will depend upon whether the cause of this occurrence can be discovered and remedied. For gorse, there are also a number of other promising insects to be studied. For piri-piri, research is still in the early stages, but I think the outlook for control is quite promising. The blackberry problem remains the most difficult of all; but the work must go on and every possible avenue must be explored, for the alternative to successful control by biological means would appear definitely to be a steady increase in the hold that this weed is obtaining on farm-lands in New Zealand, with disastrous consequences to the Dominion in the future.

## V. BIOLOGICAL CONTROL OF NOXIOUS WEEDS IN AUSTRALIA.

The changed outlook towards this problem in Australia must be placed to the credit of the marked success now being attained in the work against Prickly Pear. Not only has the general public reacted very favourably towards the new line of research, but the Legislatures of the Commonwealth and States are now favourably disposed towards it. Consequently the way was opened towards the organisation of further researches along the same lines in Australia, and, in my original report to the Council of Scientific and Industrial Research in 1927, I recommended that, when the Division of Economic Entomology was formed, a full Section should be

allocated for research on the Biological Control of Noxious Weeds. The scheme classified the weeds to be studied into two groups, as follows:—

(a) Weeds on which no research is being carried out elsewhere:—

St. John's Wort (*Hypericum perforatum*).

Hoary Cress (*Lepidium draba*).

Saffron Thistle (*Kentrophyllum lanatum*).

Bathurst and Noogoora Burrs (Genus *Xanthium*).

Stinkwort (*Inula graveolens*).

Star Thistle (*Centaurea calcitrapa*).

Paterson's Curse (*Echium plantagineum*).

Skeleton Weed (*Chondrilla juncea*).

(b) Weeds which are being studied at the Biological Control Laboratory, Nelson, New Zealand:—

Blackberry (*Rubus fruticosus*).

Gorse (*Ulex europæus*).

Ragwort (*Senecio jacobæa*).

In pursuance of the above policy, two quarantine insectaries have been erected at the back of the main laboratory building at Black Mountain, Canberra (Plates XVI., XVII., and XVIII.). Each of these is a modification of the original design already in use in Nelson. The principal differences in construction are related to the difference in climate as between Canberra and Nelson, the greater proportion of sunlight at the former place, the greater extremes of temperature, and the greater likelihood of damage by hail. Each insectary is about forty feet square, divided into sixteen equal units approximately ten feet square each. Each unit is supplied with a tap for watering, and eight of them can be entirely closed off as separate chambers by screens of muslin stretched on wooden frameworks, while the middle sections can also be closed off as two larger chambers each twenty feet square. A concrete path runs right round the insectary, and duck-boards are used to give access to any part for cultivation purposes. Electric light and power are provided.

The design of the baffle-chamber and attached store-room is a modification of the original Nelson design (see Text Figure). The interlocking system between the outer door and the one opening into the insectary proper is of very strong construction, while powerful springs also help to close the doors automatically after opening. The store-room has a

protected gauze window, a biological bench, and a set of shelves. The baffle-chamber itself is painted dull olive green, and its inner door has, on the insectary side, a strongly built box-cage with glass-funnel entry, for recapture of any insect that might accidentally obtain access to the baffle-chamber.

The panels of the insectary proper are partly of phosphor-bronze gauze, sixty meshes to the inch, and partly of reinforced glass. The amount and arrangement of the glass panels differ in the two insectaries, thus affording a basis for comparative observations on the effect of glass panels on the heating of the interior and the growth of plants. The roof is of reinforced glass (hail-proof), and is not raised as high as in the Nelson Insectary; but, on the other hand, a more complete system of ventilation has been secured.

For the work on Noxious Weeds, Mr. G. A. Currie, late of the Entomological Branch of the Department of Agriculture and Stock, Brisbane, has been appointed Entomologist-in-charge, working under my personal direction. At Farnham Royal, Mr. S. Garthside, Junior Entomologist of the Section, is working chiefly on the insects attacking *St. John's Wort* in Europe. A research student, Mr. S. G. Kelly, is working on the problem of insects attacking *Xanthium*, under Professor G. A. Dean, Department of Entomology, Kansas State Agricultural College, Manhattan, Kansas.

*St. John's Wort* (*Hypericum perforatum*) was the first noxious weed to be studied, for several reasons. Botanically, it is sufficiently isolated to indicate a reasonable chance of the insects feeding upon it being confined to the genus *Hypericum*. Economically, it is a very bad weed indeed, as it takes complete possession of the land, killing off every other plant except only trees and strong shrubs. Even bracken goes under to it. It will take possession of any type of land except such as is essentially either swampy, on the one hand, or not receiving a rainfall of about twenty-five inches a year on the other. It is also a poisonous plant, causing acute dermatitis in horses and cattle with any white colouring on them; sheep can eat it for a time only, but suffer greatly if the diet is continued for any length of time. At the present time, an area estimated at from 250,000 to 400,000 acres in Victoria is badly infested with this weed, chiefly in the Ovens River Valley and the more mountainous portions of Gippsland. There are also serious infestations near Tumbarumba and Mudgee, New South Wales, and smaller ones in South Australia and Tasmania. The indications are that land in-

vaded by this weed soon becomes entirely covered with it, and goes out of cultivation for good. Those who know the plant in England as a rather delicate, beautiful herb, seldom more than a foot in height, would be astonished beyond measure to see it growing in dense masses up to more than five feet in height in Victoria, a single plant producing as many as fifty upright stems, each with immense masses of flowers in large heads.

Salting has been tried with some success for this weed, but the process is costly, and, as soon as the effect of the salt has worn away, seedlings spring up in great abundance. A somewhat cheaper and more effective method appears to be the use of a solution of sodium chlorate; but this again cannot be used on the immense areas of mountainous country infested in Victoria.

A preliminary study carried out by Miss Nellie Paterson, B.A., of Cambridge University, in 1926-7, indicated the value of certain species of beetles of the genus *Chrysomela* in controlling this weed. This work has been continued by Mr. S. Garthside at Farnham Royal, who has found three species of this genus attacking the weed, viz., *C. hyperici*, *C. varians*, and *C. didymata*. A long series of tests on a wide variety of economic plants, including all the most useful types of vegetable and field crops, small fruits, cereals, grasses, fruit trees, and garden flowers, shows that these beetles do not feed on anything but *Hypericum*, either in the larval or adult stages. This initial measure of success is most promising. A permit has now been issued for the importation, under quarantine restrictions, of these species of *Chrysomela*, and the first consignment of them is due to arrive in Canberra in October, 1929. Meanwhile Mr. Currie and myself have visited all the chief centres of infestation in Australia, and have studied the ecology of the weed very fully. Large supplies of healthy plants have been brought back from various districts and planted out in No. 1 Insectary, and a wide range of economic plants is also being grown in the same insectary for the purpose of repeating the economic tests under Australian conditions.

Mr. Garthside has also done a considerable amount of work on the species of gall-midges (family Cecidomyiidae) which attack *Hypericum*, and has studied some Lepidopterous larvæ which attack the plant, the most promising being the Tortricid moth *Lathronympha hypericana*.

The present position as regards the work on biological control of St. John's Wort may be said to be most promising.

It is yet too early to be certain that the valuable insects already discovered, that will attack this weed, can all be successfully acclimatised in Australia, but the prospects are hopeful. The gall-midges present a difficult problem in acclimatisation which has not yet been overcome, as the adults are extremely delicate flies that only live for a day or two. Acclimatisation of beetles is always a difficult matter, and much still remains to be done in improving the technique of this type of work, and in discovering the causes that lead to infertility in such cases. An effective seed-capsule feeder has yet to be found to complete the attack. The progress made, however, after little more than a year's work, is at least as rapid as it was in the case of the Prickly Pear insects.

The problem of the Cockle Burrs (genus *Xanthium*) is a most interesting one from the point of view of biological control. In Australia we have the well-known Bathurst Burr (*X. spinosum*) and the even more troublesome Noogoora Burr (probably *X. pungens*, but authorities do not yet agree as to the exact species). These are annual herbs spread by means of the seed. Noogoora Burr, more particularly, is rapidly gaining ground in Southern Queensland. Botanically, it is a curiosity, in that the capsule contains two large seeds, one of which germinates the summer after ripening, while the second lies dormant until the following season. Thus the chance of the weed surviving is greatly enhanced, and the occupation of new areas of land by seed spread about over rich flats by means of flooded rivers is made very easy. Noogoora Burr, in fact, is the outstanding weed problem of Queensland, now that Prickly Pear is well on the way to being controlled.

The genus *Xanthium* is classified as a member of the Natural Order Compositæ, but differs markedly from most genera in that Order, in that the plant, which is monoecious, bears unisexual flowers, the male flowers maturing before the female. The seed-capsule is covered with strong hooks which catch in the wool of sheep, causing losses to the wool industry which must run into very high figures, though no attempt has been made to estimate them at all accurately. From the point of view of biological control, the problem is a fairly favourable one. It is true that the Order Compositæ contains some valuable economic plants, such as Lettuce and Jerusalem Artichoke, and a large number of ornamental garden plants; but the genus *Xanthium* stands far enough

apart from all these to make it reasonably certain that a considerable number of the insects that feed upon it naturally will not attack other genera. In particular, if a species can be found that feeds inside the seed-capsule, it will be extremely unlikely to attack the seeds of other Compositæ, since it is here that the genus *Xanthium* is most specialised. A search for this type of insect is now being carried on by Mr. Kelly in North America.

Some preliminary work has already been carried out regarding the Thistles, Hoary Cress, and Skeleton Weed, but not much progress can be made with these until more workers can be added to the staff. In the case of Hoary Cress, the problem is a most difficult one, almost as bad as that of Blackberry; for this weed is not only a "double-header" (i.e., it spreads easily in two ways, either from the seed or from any broken or cut portion of the underground stem), but it is closely related to a host of valuable economic plants of the Natural Order Cruciferae. Skeleton Weed is also a difficult problem, as it is another "weed of cultivation," being spread mainly from the broken pieces of the underground stem left in ploughed land; but it is not so unfavourably situated botanically as is Hoary Cress.

Turning to the weeds already being studied at the Cawthron Institute, Nelson, New Zealand, work has already been begun upon Ragwort (*Senecio jacobææ*). A portion of No. 1 Insectary has been planted with this weed, both well-grown plants and seedlings, and a plot of ground in the open has also been planted with them. As the moth *Tyria jacobææ* has already passed all necessary tests satisfactorily in New Zealand, permission has been given for its importation into Australia without further testing. The first consignment of pupæ was brought over from New Zealand by Mr. Tonnoir this month (September, 1929), and the moths are shortly due to begin emerging. I have already indicated to you that the principal obstacle to success, in the case of this moth, is caused by the great abundance of the common allied species *Nyctemera annulata* in New Zealand, and the resulting possibility of the work of *Tyria* on ragwort being checked by the attacks of the known parasites of *Nyctemera*. As far as my observations go, it would appear that the allied Australian species *Nyctemera amica* is not particularly common in ragwort-infested areas, so that the prospects of success for *Tyria* in Australia may be considered more promising than in New Zealand on this point. On the other hand, the

climate of Australia may not prove to be quite as suitable for the moth, which is confined in nature to the cooler parts of Western Europe.

Blackberry is, of course, a very bad pest in parts of Australia. No work, however, can be undertaken on this weed here pending the completion of the researches at present being carried out at the Cawthron Institute. We must be content with the assurance that every possible avenue of control will be explored; should any one of them prove successful, the results will be almost immediately available for Australia. The same remarks apply to gorse.

I have now outlined to you the relationship of the special problem of Noxious Weeds Control to the problem of Biological Control in general, and have shown that this type of work rests upon a secure scientific foundation. This has been followed by a general survey of the types of problem presented by different kinds of weeds. In subsequent sections of this lecture, I have dealt with the history of Biological Control of Noxious Weeds, taking, in chronological order, the four examples of this type of work that have been, or are being, undertaken, viz., the Hawaiian experiments, the Prickly Pear work in Australia, the work at the Cawthron Institute, Nelson, New Zealand, and the work now being carried on at the Central Entomological Laboratory of the C.S.I.R. at Canberra. If I have thereby succeeded in enabling you to grasp the immense importance of the problem to Australia, its innate difficulties as well as its splendid promise in individual cases, I shall feel that the main purpose of this lecture has been achieved.

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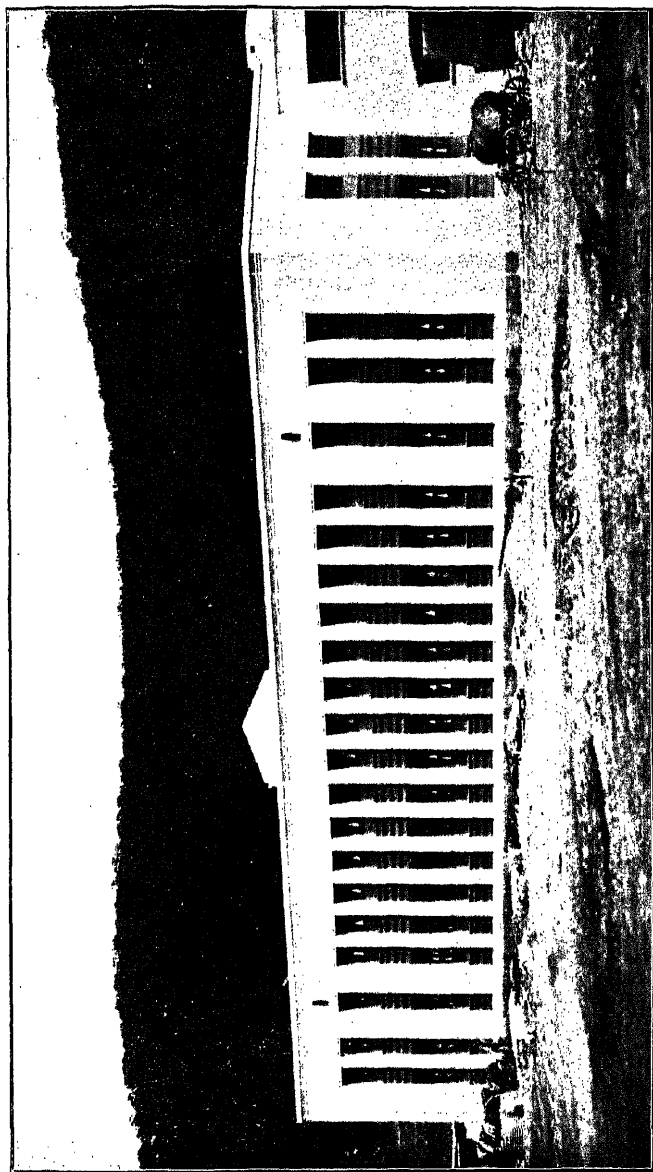
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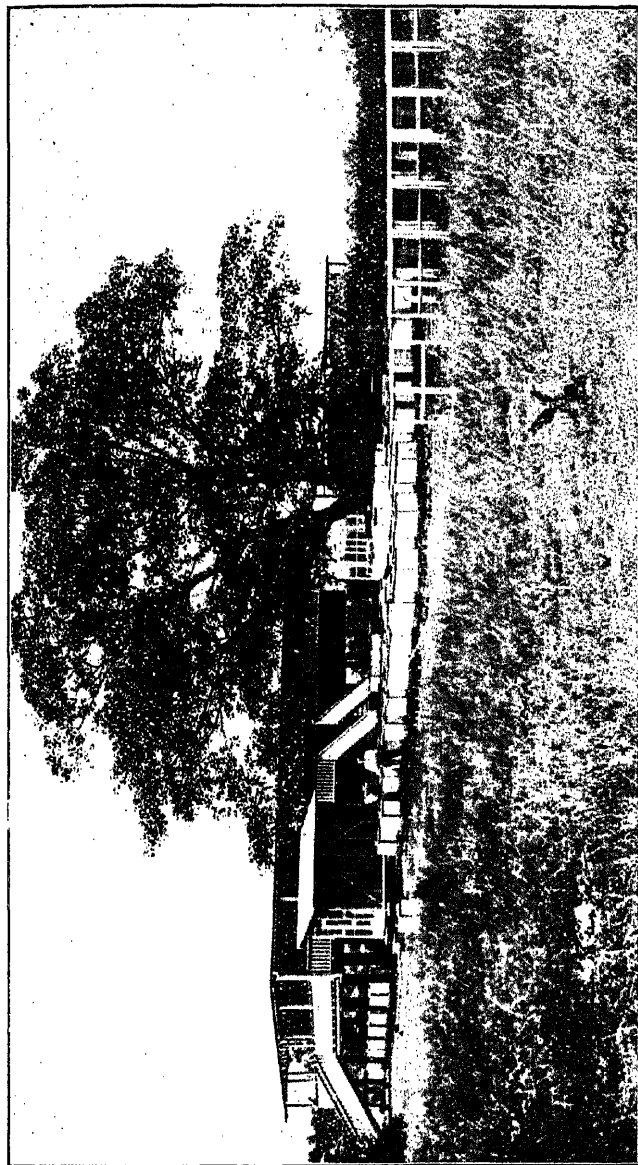
Front elevation of the new Laboratory Block, Division of Economic Entomology, C.S.I.R., Black Mountain Site, Canberra, Australia. This building is designed to house the left wing of the new building, leaving a central Administrative Block and a right wing similar to the left for the Division of Economic Botany. (Photo, by J. Mildenhall.)





The Experimental Station of the Hawaiian Sugar Planters' Association, Honolulu, Hawaiian Islands.





Central Laboratory of the Prickly Pear Board, Sherwood, near Brisbane, Queensland. In front, to left, a small insectary; in middle, rows of breeding cages.

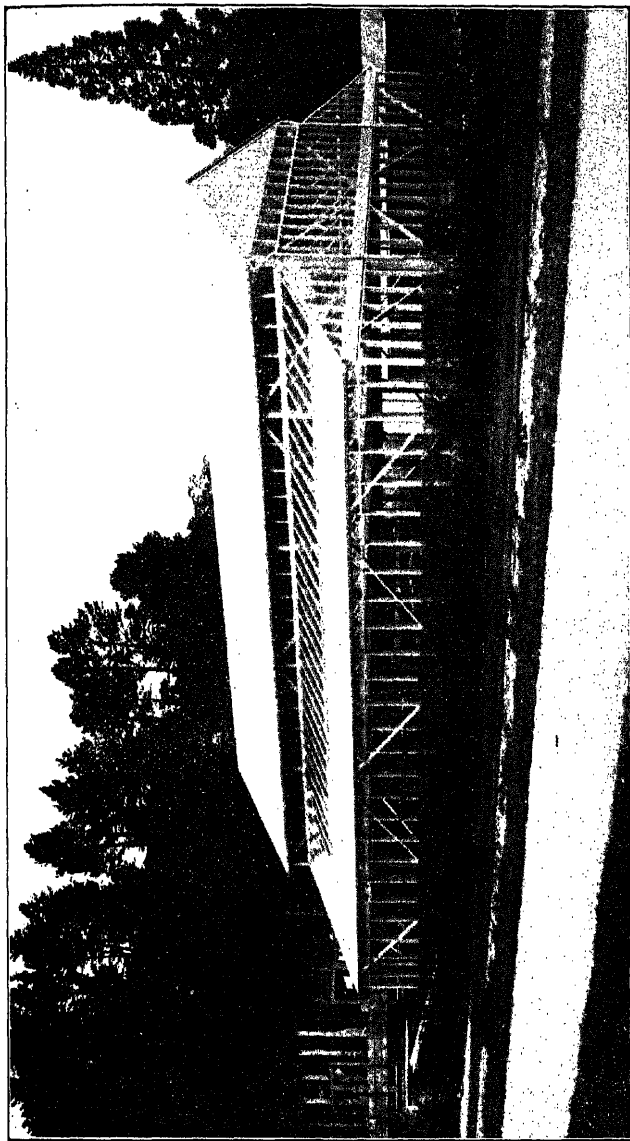






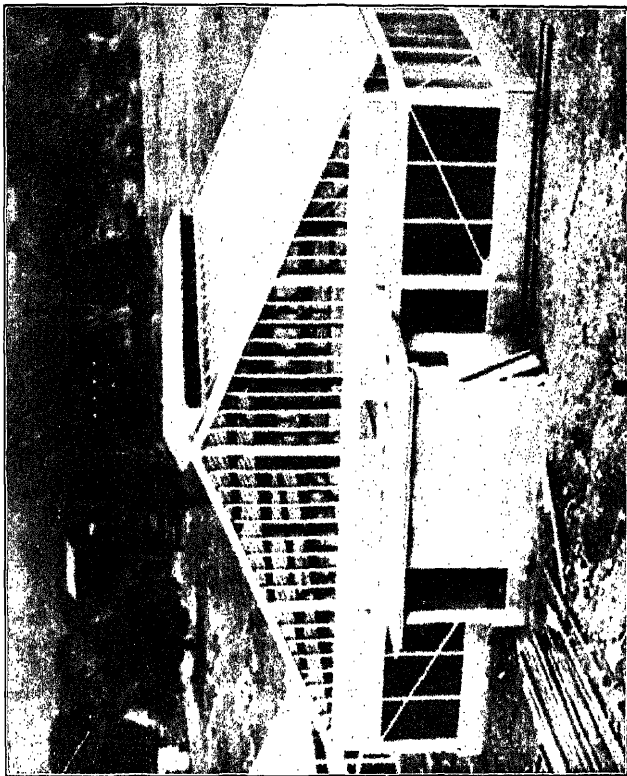
Portion of The Wood, Nelson, New Zealand, with harbour in background, showing in foreground the Bological Control Laboratory and insectary of the Cawthron Institute. Photo. taken from the grounds of the Cawthron Institute. (Photo. by W. C. Davies.)





The large Quarantine Insectary of the Biological Control Station at the Cawthron Institute, Nelson, New Zealand. Note the raised roof with side ventilation between middle and side portions.





No. 1 Quarantine Insectary of the Division of Economic Entomology, C.S.I.R., Canberra, F.C.T., Australia, showing Baffle Chamber with door open to left; the quarantine store-room is the chamber with small window attached to right of baffle chamber. Note the roof-ventilation.

1875

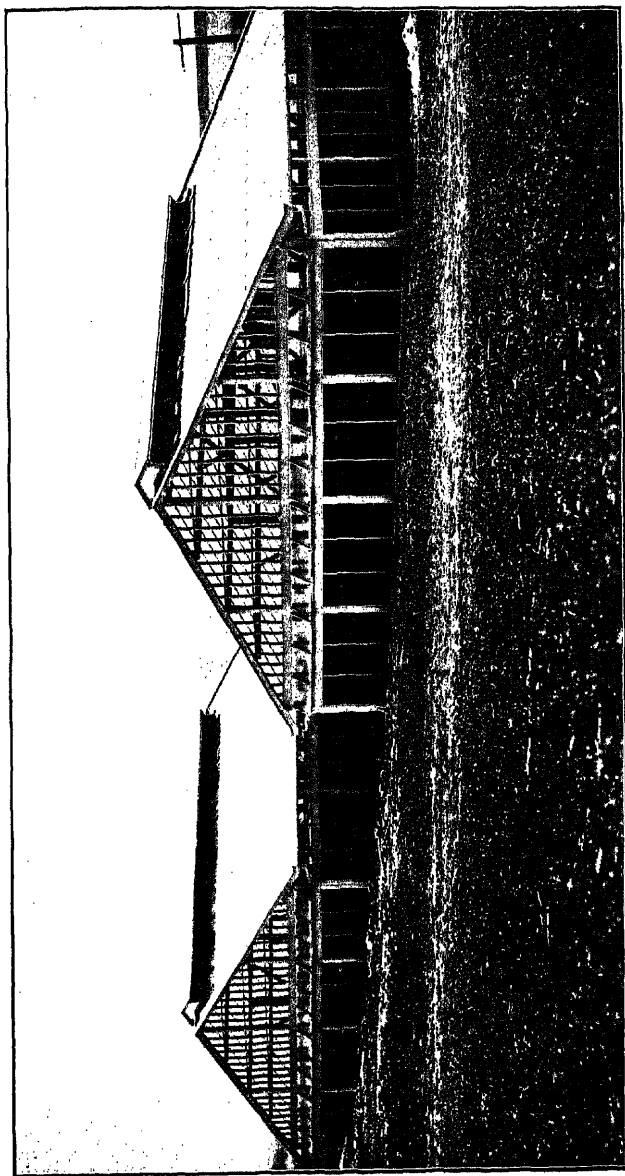
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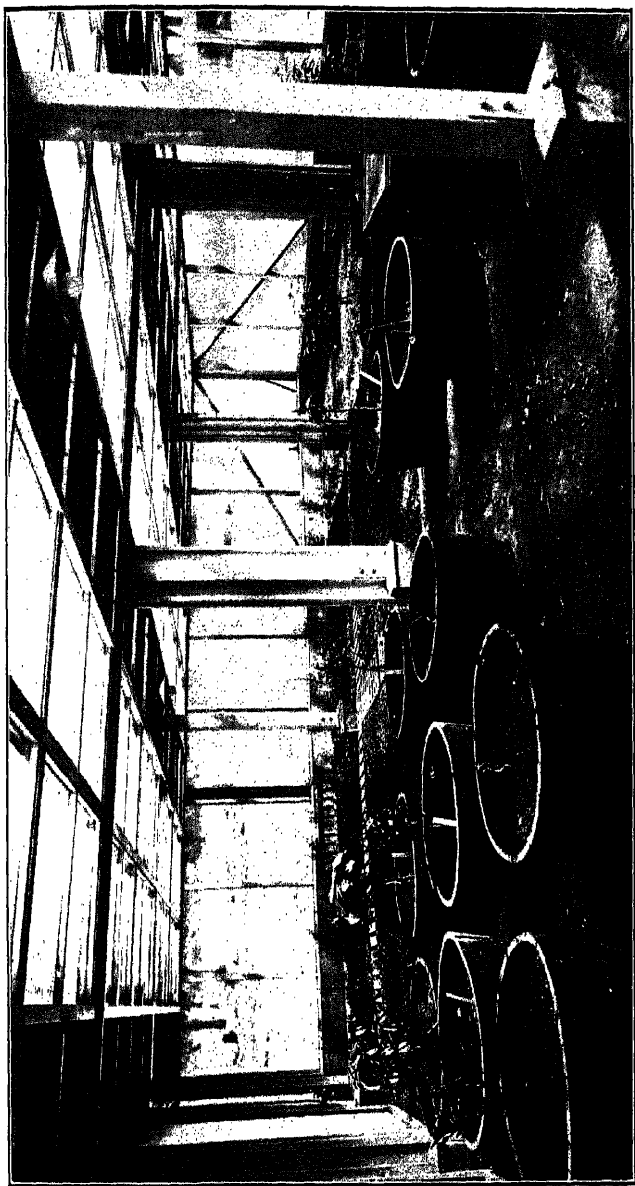
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Nos. 1 and 2 Quarantine Insectaries of the Division of Economic Entomology, C.S.I.R., Canberra, F.C.T., Australia, viewed from the back showing complete roof and side ventilation.







Interior of No. 1 Quarantine Insectary, Division of Economic Entomology, C.S.I.R., Canberra, F.C.T., Australia. In foreground, tubs containing fruit-trees for feeding tests on imported insects; in background, plots of St. John's Wort (*Hypericum perforatum*).



## STUDIES IN TASMANIAN SPIDERS.

## PART IV.

By

V. V. HICKMAN, B.A., B.Sc.

Plates XIX-XXVI., and Nineteen Text Figures.

(Read 11th November, 1929.)

The present paper deals with five new species of spiders, one of which forms the type of a new genus in the *Oonopidae*. I have adopted the scheme of classification proposed by Professor A. Petrunkevitch of Yale University in his *Systema Araneorum*, (1) and have also made use of his helpful terminology and notation of spines, a full explanation of which is given in his paper on the *Arachnida* from Panama. (2) The term "Tibial Index" has been introduced by him and is explained in his paper on the spiders of Porto Rico. (3) I am very much indebted to him for copies of the above papers. My thanks are also due to Mr. A. Musgrave of the Australian Museum for a copy of Walckenaer's description of *Miturga necatrix*, and to Mr. S. Butler of Melbourne for other papers not obtainable in Tasmania.

Unless otherwise indicated all descriptions have been made from specimens preserved in alcohol.

## Family DIPLURIDÆ.

## Sub-Family DIPLURINÆ.

Genus *Aname*, L. Koch.*Aname pexa*, sp. nov.

## Plate XIX.

*Male*. Measurements in millimetres.

Total Length (excluding palps and spinnerets) . . . . .	13.0
Length of Cephalothorax . . . . .	7.0
Breadth of Cephalothorax . . . . .	5.2
Length of Abdomen . . . . .	6.5
Breadth of Abdomen . . . . .	4.5

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Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	5.5	3.1	4.0	4.5	3.0	20.1
2	5.2	3.0	3.8	4.5	3.0	19.5
3	4.5	2.5	3.0	4.0	3.0	17.0
4	6.0	3.0	5.0	5.3	3.5	22.8
Palpi	3.0	1.7	2.3	—	1.1	8.1

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Width of first patella at "knee" 1.044 mm. Tibial Index 14.

Width of fourth patella at "knee" 1.160 mm. Tibial Index 14.

*Cephalothorax*: Brown, clothed with fine recumbent grey hairs, and a few short erect black hairs. Front narrow (2.9 mm) and truncate, sides well rounded and fringed with black bristles which increase in size and number towards the rear. Posterior very slightly emarginate. The head part slightly raised, thoracic part somewhat flat, the slope from front to rear being gradual. Radial grooves distinct but not deep.

*Thoracic fovea*: Deep and recurved. This is remarkable since in the female the fovea is almost straight or very slightly procurved. Procurvature is the normal condition in this genus.

*Eyes*: The eye tubercle is close to the front margin. Its transverse axis is longer than its longitudinal axis in ratio 4 : 3. It is black in colour and provided with a few black bristles in front of AME and between PME. Eyes in two rows, the front row being strongly procurved, the rear row slightly recurved. Ratio of eyes AME : ALE : PME : PLE = 5 : 6 : 4 : 5. The eyes are golden yellow in colour in specimens preserved in alcohol. The diameter of the pupil of AME is four-fifths of the diameter of the latter. The space between the pupils of the AME is equal to half the diameter of the pupil. ALE separated from PLE by a space equal to that between the pupils of AME. The distance separating the ALE from the AME is equal to three-fifths of the diameter of the latter. The PME almost touch the PLE. The space between the PME is equal to four times that between the pupils of AME. The eyes are elliptical in shape except the AME which are circular. (Text Figure 1.)

*Legs:* 4, 1, 2, 3. Dark brown, clothed with fine recumbent grey hairs, coarse black hairs and black bristles. There is no apophysis on the first pair of tibiae. All tarsi are lightly scopulate to base. The first and second metatarsi also lightly scopulate to base. A very slight scopula at the apex of the third metatarsi, none on the fourth pair. The superior tarsal claws long and curved with a double row of pectinations, there being about twelve long teeth in each row. The inferior claw is small and bare. A single longitudinal row of trichobothria on each tarsus and metatarsus. Two rows of trichobothria on each tibia.

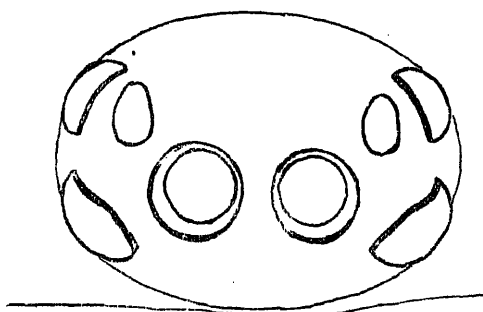


Fig. 1. *Aname peza*, sp. nov.  
Eyes in the male.

*Palpi:* Colour and clothing like that of the legs. Bulb pyriform, ending in a short blunt flat twisted style. (Text Figure 2.)

*Spines:* *First leg.* Femur—dorsal 1-1-1-1p, elsewhere 0. Patella—dorsal 0, prolateral 1-2-1, retrolateral 0, ventral 1 near apex. Tibia—dorsal 0, prolateral 2-1-1, retrolateral 1-1-1, ventral 2-1-2-3, the three at apex. Metatarsus—ventral 1 at apex, elsewhere 0. *Second leg.* Femur—dorsal 1-1p-1p, elsewhere 0. Patella—dorsal 0, prolateral 1-1-1, retrolateral 0, ventral 0. Tibia—dorsal 0, prolateral 1-1-1, retrolateral 0, ventral 2-3-3. Metatarsus—dorsal 0, prolateral 1-1, retrolateral 0, ventral 1-2-1. *Third leg.* Femur—dorsal 2-2-1, prolateral 1-1-1, retrolateral 0, ventral 0. Patella—dorsal 1, prolateral 1-1-1-1, retrolateral 1-1, ventral 0. Tibia—dorsal 1, prolateral 1-1-1, retrolateral 1-1, ventral 2-3-3. Metatarsus—dorsal 1 in the middle, prolateral 1-1-1, retrolateral 1-1-1, ventral 2-2-3. *Fourth leg.* Femur—dorsal 1-1-2-1, elsewhere 0. Patella—retrolateral 1, elsewhere 0. Tibia—dorsal 0, prolateral 1

near the base and 1 at the apex, retrolateral 1-1-1, ventral 2-1-2-2. Metatarsus—dorsal 2 apical, prolateral 1v-1-1, retrolateral 1-1, ventral 2-2-3. There are no spines on any of the tarsi. *Palpi*. Femur—dorsal 1 near apex, elsewhere 0. Patella 0. Tibia—prolateral 2 near middle, elsewhere 0.



Fig. 2. *Anamoc pexa*, sp. nov. ♂  
Left palpus of male viewed from below.

*Falces*: Dark brown, not very powerful, 1.9 mm. long. Clothed with black bristles and fine recumbent grey hair, except on the middle of the dorsal surface, where there is a longitudinal bare patch. No rastellum is present. Fang moderately long and well curved, reinforced by four narrow longitudinal ridges. Promargin of furrow armed with eight strong teeth, while thirteen minute teeth form a group at the base of the furrow. Retromargin provided with a scopula of long red hairs but no teeth.

*Maxillæ*: Brown except the promargin which is very light brown. Clothed with black hairs and provided with a reddish scopula along the whole length of the promargin except the uppermost end of the upper angle. Near the base is a group of twenty three small cuspules.

*Labium*: Brown, subconical, truncate in front, broader than long in ratio 17 : 10. Clothed with long bristles in front and a few black hairs over the surface. Only two small cuspules present near the front.

*Sternum*: Long oval in shape, light brown, procurved round base of labium in front, clothed with black bristles which are fine in the central area but become coarse round the margin. The edge of the margin is slightly reflexed and fringed with short fine grey hairs. *Sigilla* small, anterior pair marginal and not very distinct, middle pair marginal, the rear pair largest and removed from the margin by a space equal to their long diameter. The fourth pair of coxæ are contiguous in rear of the sternum.

*Abdomen*: Ovate, the dorsal surface dark brown blotched with patches of fawn on each side of middle line. Clothed with fine recumbent grey hair and long coarse black bristles. Ventral surface fawn blotched with brown, clothed with fine grey hair and short thin bristles.

*Spinnerets*: Fawn in colour, clothed with dark grey hairs. Superior pair 2.37 mm. long. Ratio of joints, basal : middle : apical = 19 : 11 : 11. Separated by a space equal to twice their individual diameter at the base. Inferior pair small and club shaped, 0.58 mm. long, separated by a little more than once their individual diameter at the base.

*Locality*: Prince of Wales Bay, Derwent Park. 21st May, 1923.

*Field Notes*: This spider was found in a silken tube under a stone. The site was only a few yards away from the spot where the females were found some years later.

*The Female.* Measurements in millimetres.

Total length (excluding falcæ and spinnerets) . . . . .	22.0
Length of Cephalothorax . . . . .	9.5
Breadth of Cephalothorax . . . . .	7.0
Length of Abdomen . . . . .	12.5
Breadth of Abdomen . . . . .	8.5



---

Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	7.0	4.0	5.0	5.0	3.5	24.5
2	6.0	4.0	4.5	4.5	3.0	22.0
3	5.0	3.5	3.0	4.0	3.0	18.5
4	7.0	4.0	5.5	5.5	3.5	25.5
Palpi	4.0	3.0	3.0	—	3.5	13.5

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Width of first patella at the "knee" 1.3. Tibial Index 14.

Width of fourth patella at the "knee" 1.5. Tibial Index 16.

*Cephalothorax*: Truncate in front, sides slightly rounded, emarginate in rear, arched from side to side and sloping gently from front to rear. Light brown in colour, clothed with soft fine recumbent grey hairs and a few coarse black hairs. The sides and rear margin are fringed with black hairs.

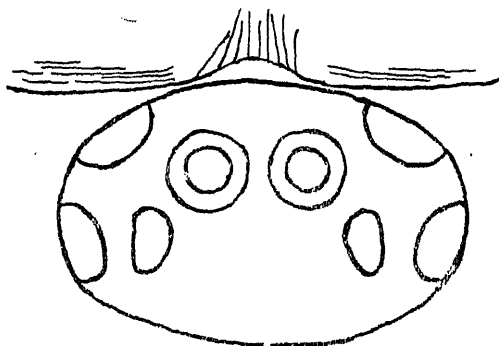


Fig. 3. *Aname pexa*, sp. nov.  
Eyes in female.

*Clypeus*: Narrow, fringed with nine black bristles in front of eye-tubercle.

*Thoracic Fovea*: Deep, slightly procurved, situated one third from posterior margin.

*Eyes*: The eye-tubercle is high, oval, black in colour except behind the rear row of eyes and between the PME where it is brown. Its transverse axis is longer than its longitudinal axis in the ratio 28:17. The eyes are arranged in two rows. The front row is procurved and the rear row recurved. (Text Figure 3.) Ratio of eyes AME : ALE :

PME : PLE = 7 : 7 : 5 : 5.5. The pupil of AME has a diameter four-sevenths that of the latter. PME irregular in outline, angular, white. The ocular quadrangle is wider in rear than in front and much wider than long in ratio 28 : 13. The laterals are separated by three-sevenths of the diameter of ALE. The pupils of AME are separated from each other by five-sevenths of the diameter of ALE, and the PME are separated from each other by one and five-sevenths of the diameter of ALE. Bristles are present on the eye-tubercle in front of and behind the AME.

*Legs:* 4, 1, 2, 3. Brown, clothed with black bristles and fine recumbent grey hairs. All the tarsi are scopulate to base, the scopulae on the first two pairs being very dense, somewhat thinner on the third pair, whilst in the case of the fourth pair only the prolateral and retrolateral surfaces are scopulate, the ventral surface being clothed with bristles. The first and second metatarsi scopulate to base, the others devoid of a scopula. Three tarsal claws. The inferior claw is very small and bare, the two superior claws large, well curved and possessing a double row of teeth. The double row in the case of the first leg of the right side is made up of an outer row of six teeth and an inner row of five teeth on each of the two superior claws, but this number shows considerable variation in other claws. Trichobothria are present in two rows on all tibiae, in a straight row on all metatarsi and in a zig-zag row on all tarsi. (Text Figure 4.)

*Palpi:* Brown, clothed like the legs with black bristles and fine hairs. Tarsus densely scopulate. Claw with a double row of teeth. Trichobothria in a double row on the tibial segment and in a zig-zag row on tarsus.

*Spines:* *First leg.* Femur—prolateral 1 at apex, elsewhere 0. Patella 0. Tibia—dorsal 0, prolateral 1-1, retrolateral 0, ventral 1-1-3, the three apical. Metatarsus—ventral 1 near middle, 1 apical, elsewhere 0. *Second leg.* Femur—prolateral 1 at apex, elsewhere 0. Patella 0. Tibia—dorsal 0, prolateral 1-1, retrolateral 0, ventral 1-1-2. Metatarsus—ventral 1-2-1, elsewhere 0. *Third leg.* Femur 0. Patella—prolateral 2, elsewhere 0. Tibia—dorsal 1 near middle, prolateral 1-1, retrolateral 1-1, ventral 1-1-3, the three apical. Metatarsus—dorsal 1 near middle, prolateral 1d-1v-1v-1d, retrolateral 1-1-2, ventral 2-2-2. *Fourth leg.* Femur 0. Patella 0. Tibia—dorsal 0, prolateral 0,

retrolateral 1-1, ventral 2-2-2. Metatarsus—dorsal 3 apical, prolateral 1-1, retrolateral 1 in middle, ventral 2-2-3. There are no spines on any of the tarsi.

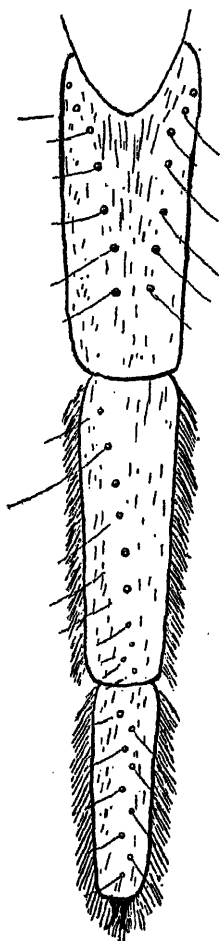


Fig. 4. *Aname peza*, sp. nov.

Leg I. of female, showing trichobothria on tibia, metatarsus, and tarsus.

*Falces*: Black, powerful, 4.0 mm. long, clothed with black bristles on the dorsal surface except near the base. No rastellum present and no stridulating organ. Fang dark brown, long and well curved; promargin of furrow armed

with ten strong teeth, retromargin with a red scopula but without teeth. At posterior end of furrow there is a group of sixteen small teeth. (Text Figure 5.)

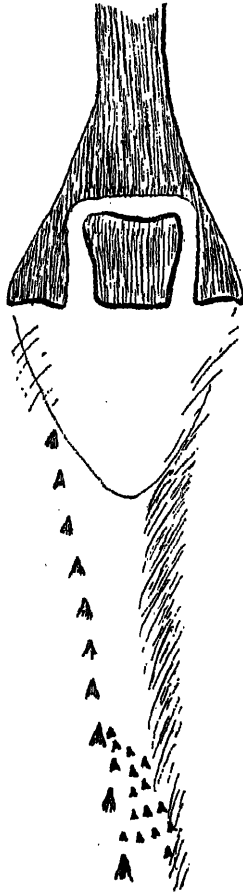


Fig. 5. *Aname peza*, sp. nov.

Underside of left falk, showing arrangement of teeth, and base of the fang in female.

**Labium:** Oval, dark brown in rear, yellowish brown in front. Broader than long in ratio 3 : 2. Clothed with long black bristles. Four cuspules in a transverse row along the front of the dark brown area.

**Maxillæ:** Outer two-thirds dark brown, inner third light yellowish brown, clothed with black bristles, a group of

forty-two cuspules near the base, promargin clothed with a thick red scopula along the whole length except the uppermost end of the upper angle.

*Sternum*: Light brown, becoming darker brown round the margin; oval in shape, being longer than broad in the ratio 17 : 13, clothed with black bristles. Anterior edge emarginate, sides angular between all coxæ. Three pairs of sigilla, oval in shape, placed opposite the first, second, and third coxæ respectively. The rear pair of sigilla are the largest and half their long diameter from the margin of the sternum. The other two pairs are nearer the margin. Coxæ of the same colour and clothing as the sternum.

*Abdomen*: Ovate, fawn in colour blotched with patches of dark brown which are largest in the middle of the dorsal surface, small and less numerous on the ventral surface. Clothed with grey hairs and fine black bristles.

*Spinnerets*: Four; the inferior pair single jointed, club shaped, clothed with short black hairs, well rounded at apex and about 1.25 mm. long, separated from each other at the base by a distance equal to one and a quarter times their individual diameter. The superior pair 4.5 mm. long, three jointed, tapering, clothed with black hairs, the lengths of basal, middle, and apical joints in the ratio 30 : 25 : 22. Separated at base by a space one and a third times wider than their diameter. Anal tubercle large and prominent.

*Locality*: Prince of Wales Bay, Derwent Park. 27th May, 1929.

*Field Notes*: The burrows were made in a bank about ten yards from the shore in a small patch of scrub. There were about thirty nests in an area of seven or eight square yards. The gradual clearing of the land round the shore of the bay has no doubt driven the spiders to seek the shelter of the few patches of scrub still remaining. The burrows were about 150 mm. deep and at the opening had a diameter of 15 mm. The mouth of the burrow was not provided with a lid but was surrounded by a collar of grass stalks and leaves. Near the bottom the diameter of the burrow increased forming a chamber in which the spider could easily turn round. Below this chamber the burrow ended in a small cavity just large enough to accommodate the spider's body. Here the spider took refuge when disturbed and drew its body into the cavity so that only its formidable falcies projected. The walls of the nest had practically no silk lining. (Text Figure 6.)

*Observations:* *Aname tasmanica*, Hogg,(4) is the only other spider belonging to this genus recorded from Tasmania. It was found by Mr. Dove at Table Cape. It differs from *Aname pexa* in the scopulation on the tarsi, in possessing no spines on the labium, in the number and arrangement of the teeth on the furrow of the falces and in the arrangement of the eyes.

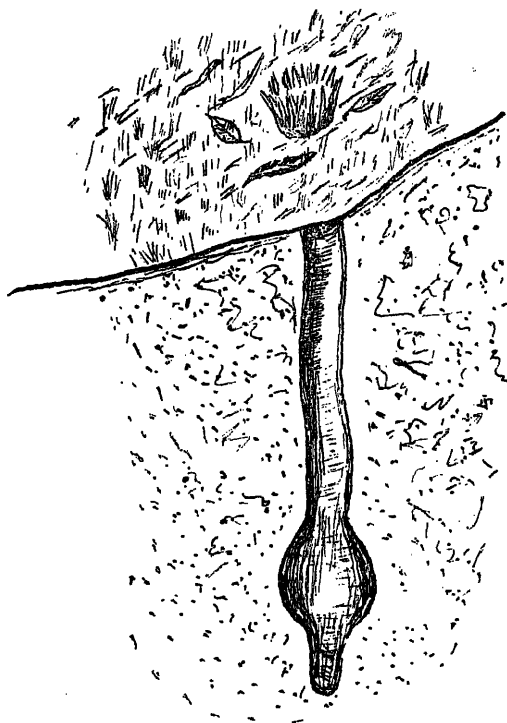


Fig. 6. *Aname pexa*, sp. nov.  
Burrow showing collar round opening.

Family OONOPIDÆ.

Sub-Family OONOPINÆ.

*Tasmanoonops*, gen. nov.

*Definition of Genus:* Cephalothorax as in the genus *Oonopinus*. No medium depression. Eyes six. When viewed from above the median eyes are in line with the ALE.

Falces without a condyle, one tooth on each side of furrow. Maxillæ slightly converging and with a scopula. The palpi of female without a claw. Posterior coxæ separated by end of sternum. Legs 4, 1, 2, 3, without a scopula but armed with spines. Tarsi end in an onychium furnished with spatulate hairs. Three tarsal claws present, the superior pair large and expanded into wing-like projections on the outer side. Inferior claw small, flat, with a bifid tip and serrated edge. Trichobothria on metatarsi and tibiæ but not on tarsi. Abdomen with two pairs of spiracles. Spinnerets six, anterior pair furnished on ventral surface with groups of short curved spines.

*Type of Genus: Tasmanoonops alipes.*

*Tasmanoonops alipes, sp. nov.*

Plate XX.

*Female.* Measurements in millimetres.

Total Length . . . . .	6.2
Length of Cephalothorax . . . . .	2.2
Width of Cephalothorax . . . . .	1.8
Length of Abdomen . . . . .	4.1
Width of Abdomen . . . . .	2.4

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Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	2.14	0.87	1.85	1.85	0.64	7.35
2	2.14	0.92	1.80	1.74	0.64	7.24
3	1.85	0.69	1.39	1.62	0.64	6.19
4	2.55	0.98	1.91	2.32	0.64	8.40
Palpi	0.75	0.35	0.46	—	0.81	2.37

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Leg 1. Width of patella at "knee" 0.232 mm. Tibial Index 8.

Leg 4. Width of patella at "knee" 0.290 mm. Tibial Index 10.

*Cephalothorax:* Uniform yellowish brown, clothed with short recumbent hair. Sides well rounded, front narrow, rear slightly emarginate. No median furrow. (Text Figure 7.)

*Eyes:* Six in number, oval in shape, mounted on black rims. The eye group is compact and arranged as shown in Text Figure 7. It occupies almost the whole width of the head. When viewed from above the median eyes form a straight line with the ALE. Ratio of eyes Median:ALE:PLE=7 : 5 : 6. The median eyes are contiguous and

separated from the ALE by a space equal to one-third of the long diameter of the former. The ALE and PLE are contiguous. One or two bristles are situated behind the eyes.

*Clypeus*: Narrow, the distance from its front edge to the median eyes being equal to four-sevenths of the diameter of the latter. It is furnished with a few bristles which project forward.

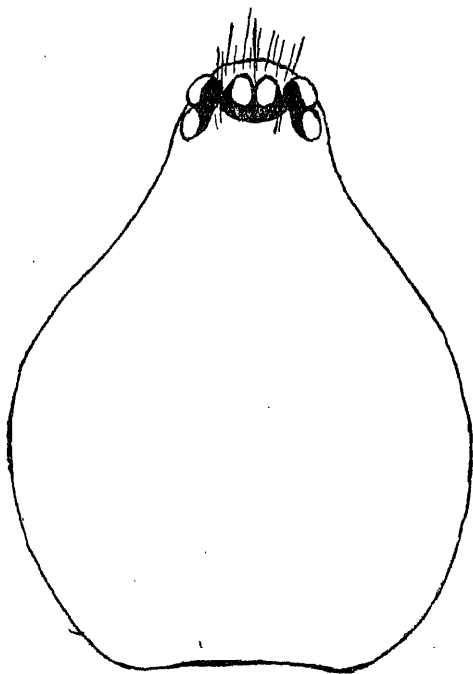


Fig. 7. *Tasmanoonops alipes*, gen. et sp. nov.  
Cephalothorax and eyes of female viewed from above.

*Legs*: 4, 1, 2, 3. Yellowish brown. Clothed with hairs which under high magnification are seen to be barbed. A single trichobothrium is present on the dorsal side of each metatarsus near the apex, and a pair of trichobothria on the dorsal side of each tibia near the middle, elsewhere none. The tarsal claws are carried on a well-developed onychium, which has a length equal to one-quarter that of the tarsus, the length of the onychium being taken from the end of the



tarsus to the base of the claws. The ventral side of the onychium is furnished with spatulate hairs, and rising from its dorsal side near the base of the claws is a pair of very long barbed hairs, whilst three similar barbed hairs occur near the base of the onychium. The tarsal claws are three in number and have a remarkable shape. (See Text Figures 8 and 9.) The superior claws are large and well curved,

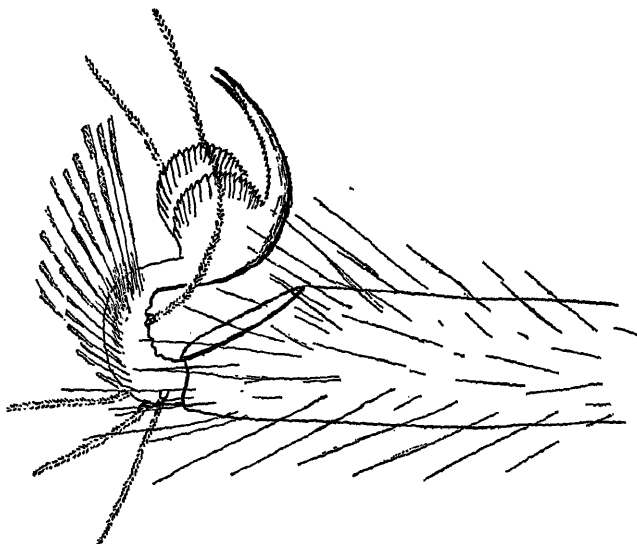


Fig. 8. *Tasmanoonops alipes*, gen. et sp. nov. ♀

Tarsal claws and onychium viewed from the side. The small third claw hidden by the spatulate hairs.

the outer side of each being expanded into a wing-like projection of translucent chitin, the outer margin of which is serrated. The inner side of the claw is normal and serrated in the usual manner. At the base of the two large claws the small third claw is situated. It has the shape shown in Text Figure 9 (b) and (c). Owing to the spatulate hairs it is difficult to see the third claw from the side, but if the end of the onychium is examined with the claws bent back over the tarsus the third claw is easily seen. The end of the tarsus slopes gently downwards so as to accommodate the claws when bent back, and the spider often walks with them in this position.

*Spines: First leg.* Femur—prolateral 2 near the middle, elsewhere none. Patella 0. Tibia—ventral 1-1,

elsewhere 0. Metatarsus—ventral 1 near middle, elsewhere 0. *Second leg.* Femur—prolateral 1 near apex, elsewhere 0. Patella 0. Tibia—ventral 1-1, elsewhere 0. Metatarsus—ventral 1 near middle, elsewhere 0. *Third leg.*

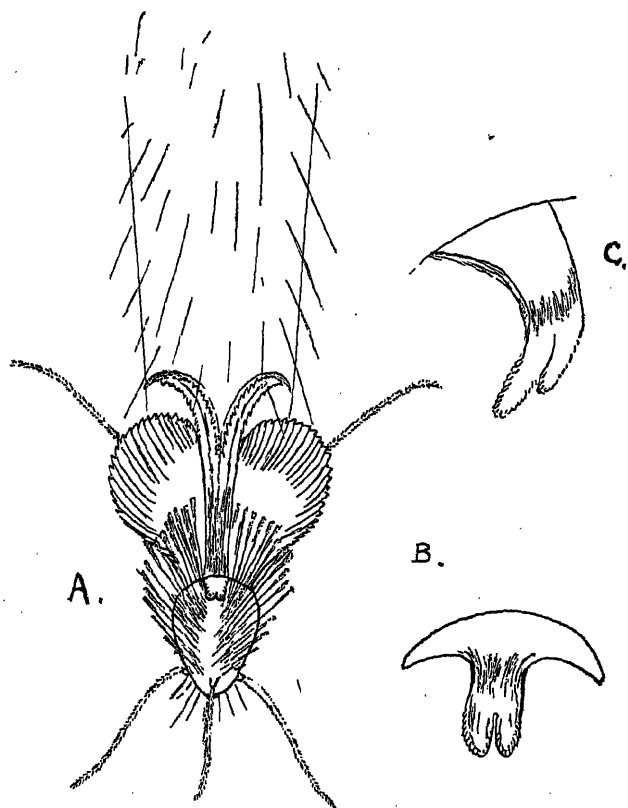


Fig. 9. *Tasmanoonops alipes*, gen. et sp. nov. ♀

(A) End view of tarsal claws and onychium folded back on tarsus.

(B) End view of third claw.

(C) Side view of third claw.

Femur 0. Patella 0. Tibia—dorsal 0, prolateral 2-2-2, retrolateral 1-1-1, ventral 1-1 and 2 apical. Metatarsus—dorsal 0, prolateral 2-1-2, retrolateral 1d-1v-1d, ventral 1 basal and 2 apical. *Fourth leg.* Femur 0. Patella 0. Tibia—dorsal 0, prolateral 1-1-1, retrolateral 1-1-1, ventral

1-1 and 2 apical. Metatarsus—dorsal 0, prolateral 2-1-2-2, retrolateral 2-1-2, ventral 1 and 2 apical. There are no spines on any of the tarsi.

*Palpi*: Light yellowish brown, clothed with long barbed hairs especially on the tarsus. No tarsal claw present.

*Falces*: Brown, conical, lightly clothed in front with a few black bristles. Fang moderately long, well curved, basal half light brown, tip dark brown. The furrow is armed with one tooth on the retromargin and one on the promargin in the position shown in Text Figure 10. The

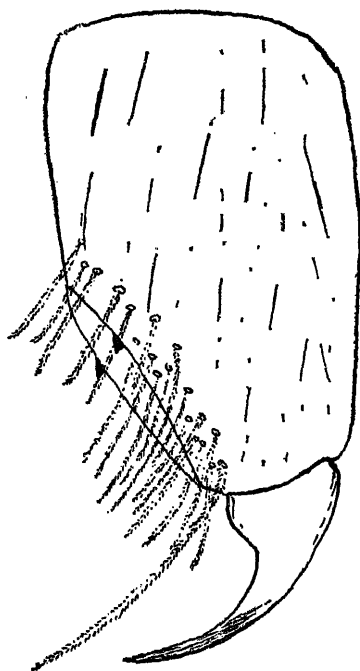


Fig. 10. *Tasmanoonops alipes*, gen. et sp. nov. ♀

Left falcx viewed from front, showing position of teeth and the barbed hairs along promargin of furrow.

promargin is also furnished with a few long barbed hairs, one of which near the base of the fang is much longer than the others.

*Labium*: Brown, subconical, free, width at base equal to length, truncate in front, and furnished with a tuft of barbed hairs at the apex.

*Maxillæ*: Yellowish brown, very slightly converging, about twice as long as the labium, the front outer margin provided with a well-developed serrula, the front inner margin with a thick scopula of long barbed hairs. (Text Figure 11.)

*Sternum*: Yellowish brown, cordiform, convex, clothed with a few black hairs. The margin is edged with a darker shade of brown and is produced into a point opposite the base of each coxa. The fourth coxæ are separated by the end of the sternum. (Text Figure 11.)

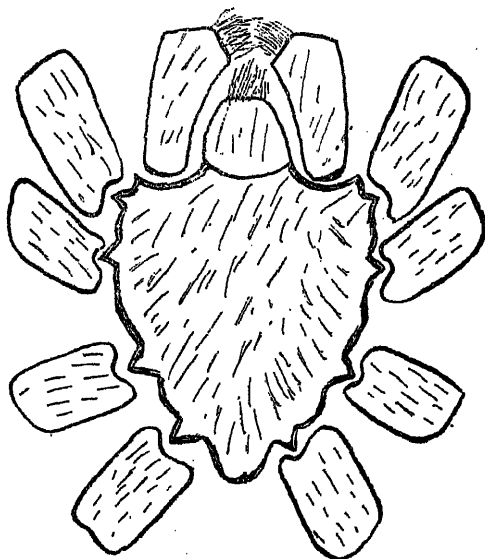


Fig. 11. *Tasmanoonops alipes*, gen. et sp. nov. ♀  
Sternum, labium, maxillæ, and coxæ.

*Abdomen*: Ovate, slightly overhanging the rear of the cephalothorax anteriorly. Grey in colour and marked with numerous faint polygonal spots. Clothed with fine hairs which under high magnification are seen to be barbed. Two pairs of spiracles are present in the normal position near the epigastric furrow on the ventral surface, the rear pair being slightly nearer the middle line than the anterior pair.

*Spinnerets*: Six; the anterior pair close together and slightly longer than the posterior pair. The middle pair small and hidden by the others. Colour and clothing like that of abdomen. On the ventral surface of the anterior

pair are a number of short curved spines. Thirteen of these form a transverse row at the apex of the segment, and about fifteen slightly larger spines are grouped in the centre of the segment. On the ventral side near the base of the anterior pair is a tuft of long hairs, among which twelve spines similar to those on the spinnerets are present. (Text Figure 12.) When viewed from the side all the spines are seen to point downwards with their tips curved towards the front.

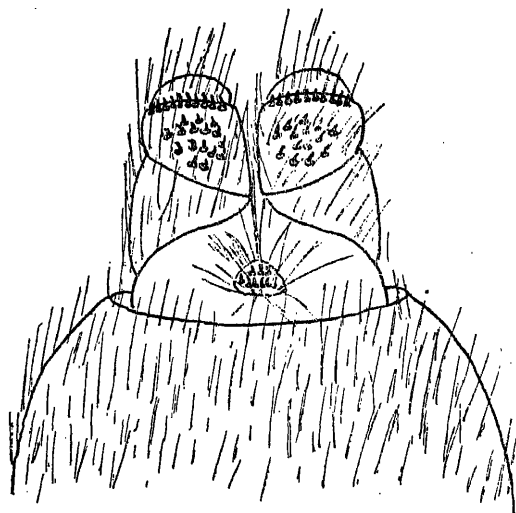


Fig. 12. *Tasmanooonops alipes*, gen. et sp. nov.  
Anterior spinnerets of female viewed from underneath and showing the spines on their ventral surface and also the spines on the tuft of bristles.

*Locality:* Mount Hobbs, Woodsdale. 13th May, 1928.

*Field Notes:* The specimen described above is the only adult specimen I have found. It was taken under a log in a cleared tract of land on the western slopes of Mount Hobbs. A second very immature specimen was found in moss at Lilydale on 23rd May, 1928, and a third specimen about three-quarters fully grown was captured under a piece of rotten wood in a gully at the Cascades, Hobart, 29th May, 1929. The last specimen was enclosed in a small cocoon-like nest of white silk.

*Observations:* This spider shows a close relationship with the *Oonopidae* in the number and arrangement of the eyes, and in possessing four spiracles, an onychium on the

tarsi, barbed hairs on the legs and body and clawless palpi. It differs, however, from the known Oonopids in its larger size, in having spines on the spinnerets, in possessing a third tarsal claw, and in the remarkable shape of the superior tarsal claws. I have therefore placed it in the new genus, *Tasmanoonops*, which has been defined above.

### Family CLUBIONIDÆ.

#### Sub-Family LIOCRANINÆ.

#### Genus *Miturga*, Thorell.

Habits and Nest of *Miturga agelenina*, Simon.

#### Plates XXI and XXII.

Simon has already recorded this spider as occurring in Tasmania and given a description of it,(5) but as far as I am aware there is no published figure of it or any account of its habits.

The spider is one of our most common species. It is found widely distributed throughout the State, being very common at South Arm, Hobart, Woodsdale, Forth Falls, Launceston, Bridport, and Burnie. It favours open, sunny situations, which are lightly wooded, and avoids the dense forest and shady gullies. Young specimens construct a tubular web, but in the case of the fully grown spider the web is generally expanded into a flat hollow structure. The silk is snow white and very fine. There is an opening at both ends of the nest. The web is generally found on the under surface of stones and logs, but sometimes it is built in a tussock of grass or in a thick shrub, especially the common gorse. In the latter case it is often two or three feet from the ground. The spider is sedentary in habits and lurks in the web waiting for its prey.

Mating takes place during November and December, when the males are to be found in the webs of the females. The egg sacs are plano-convex in shape, made of strong white silk and built into the nest. Three or four sacs are generally made.

#### *Miturga albopunctata*, sp. nov.

#### Plate XXIII.

*Female.* Measurements in millimetres.

Total Length . . . . .	16.0
Length of Cephalothorax . . . . .	7.5
Width of Cephalothorax . . . . .	5.7
Length of Abdomen . . . . .	9.5
Width of Abdomen . . . . .	6.0

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Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	4.93	2.90	3.94	3.30	2.14	17.21
2	4.75	2.90	3.71	3.07	2.14	16.57
3	4.60	2.49	3.19	3.01	2.03	15.32
4	5.80	2.90	4.98	4.87	2.30	20.85
Palpi	2.30	1.16	1.27	—	2.14	6.87

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Width of first patella at the "knee" 1.102 mm. Tibial Index 16.

Width of fourth patella at the "knee" 1.102 mm. Tibial Index 14.

*Cephalothorax*: Ovate, narrowed in front, the rear and front margins truncate, sides rounded. A broad longitudinal stripe of reddish brown extends from front to rear along the mid-dorsal line. On each side of this is a broad longitudinal stripe of dark brown, and outside this another stripe of reddish brown, while a dark-brown stripe runs round the margin. The dark-brown areas are clothed with short black hairs, and the red-brown areas with short grey hairs intermingled with a few short black hairs. Behind and between the eyes and on the sides of the head region the clothing consists of long silvery grey hairs. The median depression long, deep, and dark brown. In front of it is a faint transverse patch of brown across the reddish brown mid-dorsal stripe.

*Eyes*: In two rows; the front row slightly recurved, the rear row distinctly recurved. The rear row is longer than the front row in ratio 34 : 25. The eye space occupies a little more than half the width of the cephalothorax in the region of the eyes. It is broader than long in ratio 34 : 16. The median ocular area is longer than broad in ratio 15 : 14 and is wider behind than in front in ratio 7 : 6. The AME are separated from each other by a space equal to three-fifths of their individual diameter and from the ALE by two-fifths of their individual diameter. The distance between the PME is slightly greater than that between AME. The PLE are separated from the PME and from the ALE by a space equal to eight-fifths of the diameter of AME. All the eyes are about equal in size.

*Clypeus*: Moderately deep, the distance from its front edge to the AME is equal to seven-fifths of the diameter of the latter. It is clothed with black bristles along the front edge.

*Legs:* 4, 1, 2, 3. Dark-brown except the patellæ and distal half of the femora, which are reddish brown. They are clothed with black hairs, silvery grey hairs and black bristles. All the tarsi and metatarsi are scopulate to base. The first pair of tibiæ also show a slight scopula on the ventral surface near the apex. Trichobothria are present on all tarsi, metatarsi, and tibiæ. Tarsal claws two, short, well curved, and armed with three or four teeth. Trochanters notched.

*Palpi:* Colour and clothing as on the legs. Tarsal segment very hairy. The single tarsal claw has four teeth.

*Spines:* Those on the ventral surface of the legs very strong. *First leg.* Femur—dorsal 1-1, prolateral 1-1 near apex, elsewhere 0. Patella 0. Tibia—ventral 2-2-2, elsewhere 0. Metatarsus—ventral 2 near base, elsewhere 0. *Second leg.* Femur—dorsal 1-1, prolateral 1-1-1-1, elsewhere 0. Patella 0. Tibia—prolateral 1 very small spine, ventral 2-2-2, elsewhere 0. Metatarsus—ventral 2 large spines near base, elsewhere 0. *Third leg.* Femur—dorsal 1-1-1, prolateral 1-1-1-1, retrolateral 1-1-1-1, ventral 0. Patella 0. Tibia—dorsal 1-1, prolateral 1-1d-1, retrolateral 1-1, ventral 2-2-2. Metatarsus—dorsal 0, prolateral 1-1-1, retrolateral 1-1, ventral 2 large spines near base and 1 small spine at apex. *Fourth leg.* Femur—dorsal 1-1-1, prolateral 1-1-1, retrolateral 1-1, ventral 0. Patella 0. Tibia—dorsal 1-1, prolateral 1-1d-1, retrolateral 1-1, ventral 2-2-2. Metatarsus—dorsal 0, prolateral 2-2-2, retrolateral 2-2-2, ventral 2-2-1. *Palpi.* Femur—dorsal 1-1 and 2 close together near apex, prolateral 1 near apex, retrolateral 1 near apex, ventral 0. Patella—dorsal 1-1 bristles, prolateral 1 near apex, elsewhere 0. Tibia—dorsal 0, prolateral 2-2, retrolateral 1-1, ventral 0. Tarsus—dorsal 2 near base, prolateral 1-1, retrolateral 1-1, ventral 0.

*Falces:* Black, short, subconical, geniculate, clothed with black bristles, and provided with a reddish brown condyle at the base on the side. Fang moderately long and well curved. Promargin of furrow armed with three strong teeth and fringed with long barbed grey hairs. Retro-margin armed with two teeth. A single long barbed grey hair near the base of the fang on the retroside.

*Maxillæ:* Black, shiny, convex, short, and wide, the ratio of length to width being 33 : 20. Front edge rounded, sides slightly rounded, inner edge convex. Clothed with a few



black bristles. A scopula of dark-grey hairs on the upper half of the inner margin. (Text Figure 13.)

*Labium*: Black, shiny, wider than long in ratio 17 : 15, sides excavated in basal third, front truncated and clothed with a few coarse black hairs. (Text Figure 13.)

*Sternum*: Broadly oval, convex, truncate in front, shiny, dark red, longer than wide in ratio 9 : 8. Coxæ black; the fourth pair are contiguous in rear of the sternum.

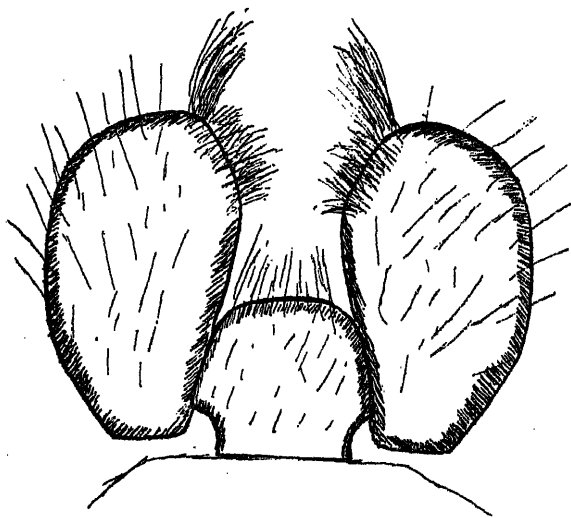


Fig. 13. *Miturga albopunctata*, sp. nov.  
Maxillæ and labium of female.

*Abdomen*: Ovate; dorsal surface light brown, clothed with black hairs intermingled with white hairs. A pair of fawn-coloured stripes, clothed with white hairs, extend from the front to about half way along the dorsum. They are followed by four pairs of white spots which are wider apart than the stripes. On the outer side of the rear end of each stripe is a large spot clothed with black hair, while each stripe has along the front half of its inner edge a thin line of black hairs. The sides of the abdomen are clothed with black hair and speckled with small white spots. The ventral surface is brown and thickly clothed with black hairs. It is decorated with four longitudinal rows of widely separated white spots composed of white hairs. Each of the two inner rows has a large spot at each end and three very small spots between the two large spots. Each of the two outer rows

has two large posterior spots and three small anterior spots. The large spots on the abdomen seem to be a constant characteristic, but the small spots vary. (Plate XXIII.) There is a tuft of white hairs on each side of the spinnerets. The epigynum is light brown and has the form shown in Text Figure 14.

*Spinnerets*: Thickly clothed with black hairs. Anterior pair contiguous, subconical, apical joint very small and dome shaped. Posterior pair longer than the anterior pair, their apical joint conical and a little more than half the length of the basal joint. Middle pair small and cylindrical.

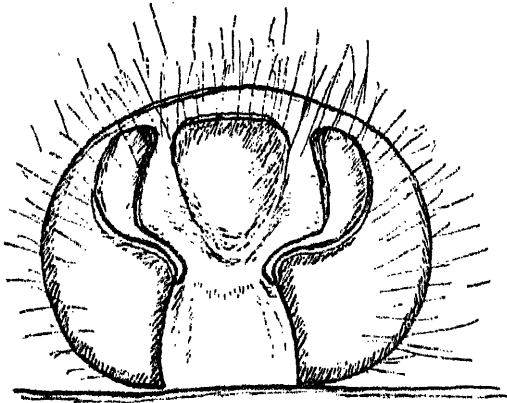


Fig. 14. *Miturga albomaculata*, sp. nov.  
Epigynum of female.

*Locality*: Daisy Dell (2,000 feet), on the road to the Cradle Mountain. December, 1927.

*Field Notes*: The spider was found under logs. Some specimens were enclosed in oval nests of white silk made between the side of the log and the grass. In one nest the spider was guarding its egg sac which is spheroidal in shape and made of white silk.

*Miturga splendens*, sp. nov.

Plate XXIV.

*Female*. Measurements in millimetres.

Total Length . . . . .	25.0
Length of Cephalothorax . . . . .	9.0
Width of Cephalothorax . . . . .	7.0
Length of Abdomen . . . . .	15.5
Width of Abdomen . . . . .	10.0

Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	7.00	3.77	5.51	4.46	3.07	23.81
2	7.00	3.77	5.28	4.35	2.95	23.35
3	6.00	3.53	4.81	4.40	2.72	21.46
4	8.00	3.77	6.78	6.20	2.95	27.70
Palpi	2.90	1.56	1.85	—	2.90	9.21

Width of first patella at the "knee" 1.276 mm. Tibial Index 13.

Width of fourth patella at the "knee" 1.276 mm. Tibial Index 12.

*Cephalothorax*: Black in the eye region and at the sides of the cephalic part; elsewhere reddish brown except the median depression, the radial grooves, and the margin, which are dark brown. Clothed with short black hairs intermingled with silvery grey hairs, the latter being moderately thick on each side of the head region. Three longitudinal stripes composed of silvery grey hair extend from between the eyes half way to the median depression. The anterior end of the median depression is 5 mm. from the front. There are a few black bristles in front of and immediately behind the eyes, as well as on the sides of the head region. Margin is fringed with silvery grey hairs.

*Eyes*: In two rows; front row slightly recurved, rear row distinctly recurved and longer than the front row. The eye space is twice as wide as it is long and occupies three-fifths of the width of the cephalothorax in the region of the eyes. Eye ratio  $AME : ALE : PME : PLE = 6 : 7 : 7 : 7$ . The AME are separated from each other by five-sixths of their individual diameter and from the ALE by one-third of their individual diameter. The PME are separated from each other by a space equal to the diameter of AME. The PLE are separated from the PME by a space equal to one and a half times the diameter of AME, and from the ALE by one and a third times the diameter of the AME. The median ocular area is longer than wide in ratio 17 : 16, and slightly wider in rear than in front in ratio 17 : 14. There is a tuft of black bristles in the middle of the area. Silvery grey hairs clothe the spaces between the eyes of the rear row and between the lateral eyes.

*Clypeus*: Black clothed with thin black bristles. The distance from the edge to the AME is equal to the diameter of ALE.

*Legs:* 4, 1, 2, 3. Tarsi, metatarsi, and tibiae nearly black in colour. The tibiae have a longitudinal reddish brown stripe on the dorsal side. Patellae and femora reddish brown. The clothing consists of short black hairs and fine recumbent silvery grey hairs. On the dorsal side of trochanters and coxae the silvery grey hairs are long and dense. Ventral surfaces of trochanters and coxae very dark brown, with a longitudinal stripe of lighter brown on the coxae. Trochanters notched. All tarsi and metatarsi scopulate to base, the scopula extending onto the apex of the tibia in the case of the first two pairs of legs. Trichobothria on all tarsi, metatarsi, and tibiae. Tarsal claws two, armed with three or four teeth.

*Palpi:* Dark brown nearly black, clothed like the legs, the single tarsal claw has three teeth.

*Spines:* *First leg.* Femur—dorsal 1-1, prolateral 1-1-1-1, retrolateral 1-1, ventral 0. Patella 0. Tibia—dorsal 0, prolateral 1 small spine near base, retrolateral 0, ventral 2-2-2. Metatarsi—ventral 2 long spines near base, elsewhere 0. *Second leg.* Femur—dorsal 1-1, prolateral 1-1-1-1, retrolateral 1-1, ventral 0. Patella 0. Tibia—dorsal 0, prolateral 1 small spine near base, retrolateral 0, ventral 2-2-2. Metatarsi—ventral 2 long spines near base, elsewhere 0. *Third leg.* Femur—dorsal 1-1-1, prolateral 1-1-1-1, retrolateral 1-1-1-1, ventral 0. Patella 0. Tibia—dorsal 1-1, prolateral 1-1d-1d, retrolateral 1-1, ventral 2-2-2. Metatarsi—dorsal 0, prolateral 1-1-1, retrolateral 1-1, ventral 2 long spines near base and 1 small spine near apex, elsewhere 0. *Fourth leg.* Femur—dorsal 1-1-1, prolateral 1-1-1-1-1, retrolateral 1 small and 1 large spine, ventral 0. Patella 0. Tibia—dorsal 1-1, prolateral 1-1d-1d, retrolateral 1-1, ventral 2-2-2. Metatarsi—dorsal 0, prolateral 1-2-2, retrolateral 2-2-2, ventral 2-2-1. *Palpi.* Femur—dorsal 1-1 and 2 close together near the apex, prolateral 1 near the apex, retrolateral 1 near the apex, ventral 0. Patella—dorsal 1-1, prolateral 1, elsewhere 0. Tibia—dorsal 1-1, prolateral 2-1, retrolateral 2, ventral 0. Tarsus—dorsal 2 near base, prolateral 1-1, retrolateral 1-1, ventral 0.

*Falces:* Black, clothed in front with black bristles, geniculate, provided with a brown condyle on the side at the base. Fang moderately long, well curved. Promargin of furrow armed with three large teeth and fringed with long barbed grey hairs. Retromargin armed with two large teeth, and provided with a single long barbed grey hair near the base of fang.

*Maxillæ*: Short and wide, the ratio of length to width being 9 : 5. Front rounded, inner edge convex, outer edge convex with a slight inward curve opposite the trochanters of the palpi. (Text Figure 15.) Colour shiny black marked with three longitudinal brown patches as in *Miturga velox*. The black areas clothed with black bristles, the brown patches glabrous. A thick grey scopula on front half of inner margin.

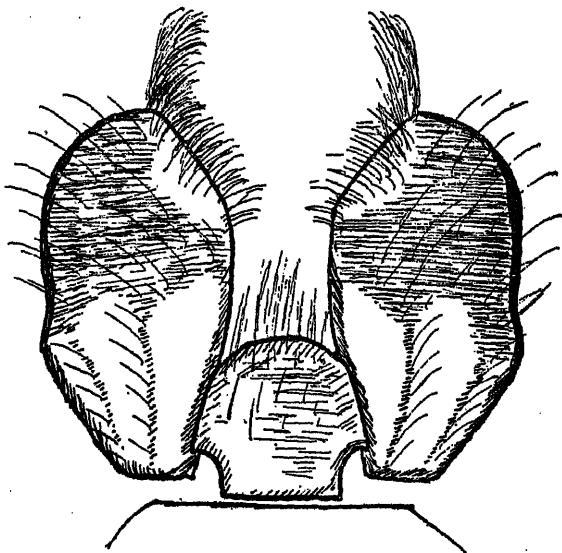


Fig. 15. *Miturga splendens*, sp. nov.  
Maxillæ and labium of female.

*Labium*: Shiny black, wider than long in ratio 8 : 7. Sides excavated in basal third; front gently curved, brown, and clothed with a few black bristles.

*Sternum*: Shiny black, clothed with black bristles, oval, longer than wide in ratio 7 : 6. Surface raised into a slight elevation opposite the base of each coxa. Margin truncate in front and angulate between the coxæ. Rear coxæ contiguous behind sternum.

*Abdomen*: Egg-shaped; dorsal surface fawn, clothed with black hairs and speckled with white spots. Intermingled with the black hairs there are fine recumbent silvery grey hairs. Seven pairs of conspicuous white spots down

the middle of the dorsum, and between each of the five rear pairs of spots are two short oblique white lines. Sides somewhat darker in colour and speckled with white spots. Ventral surface black marked with white spots, which show no definite arrangement. Epigynum is brown and has the form shown in Text Figure 16. Two large whitish spots in front of epigynum.

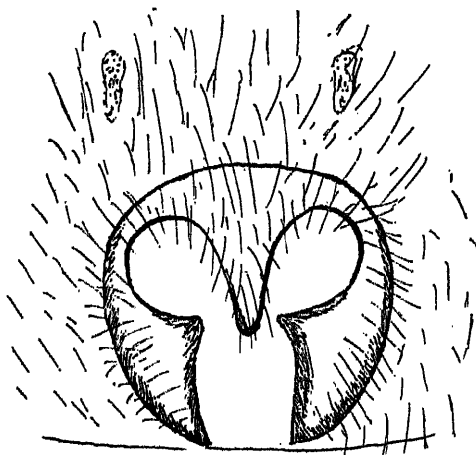


Fig. 16. *Miturga splendens*, sp. nov.

Epigynum of female.

*Spinnerets*: Clothed with black hairs; posterior pair two jointed, the apical joint conical and about two-thirds the length of the basal joint. Anterior pair subconical and shorter than the posterior pair; apical joint very small, dome shaped, and sunk in the apex of the basal joint. Middle pair about equal in length to the anterior pair, apex rounded.

*Locality*: The Quoin (1,500 feet), Ross. 6th November, 1927.

*Field Notes*: This spider was collected from under a stone by Mr. A. L. Meston, M.A. When alive it is a most beautiful species. The fine silvery grey hair with which the spider is covered produces a wonderful iridescent effect among the darker colours on the body, when the spider is in the sunlight.

*Miturga velox*, sp. nov.

## Plates XXV. and XXVI.

*Male.* Measurements in millimetres.

Total Length . . . . .	11.0
Length of Cephalothorax . . . . .	5.5
Breadth of Cephalothorax . . . . .	4.5
Length of Abdomen . . . . .	6.0
Breadth of Abdomen . . . . .	3.9

Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	4.64	2.32	4.17	4.85	2.49	17.97
2	4.64	2.03	4.06	3.77	2.32	16.82
3	4.35	2.03	3.36	3.19	1.97	14.90
4	5.22	2.32	4.75	5.51	2.14	19.94
Palpi	2.32	0.92	1.04	—	3.77	8.05

Width of first patella at the "knee" 0.696 mm. Tibial Index 10.

Width of fourth patella at the "knee" 0.754 mm. Tibial Index 10.

*Cephalothorax:* Ovate, narrow in front, sides well rounded, marked with a radiating pattern of light brown and dark brown patches. Median depression long, narrow, deep, and clothed with black hairs. The hairs on the light brown areas are silvery grey, those on the dark brown areas are black. Immediately behind the eyes the clothing of silvery grey hairs is very thick, and from it project a few short black bristles. The radial grooves distinct, their outer ends being coloured dark brown. The margin is fringed with silvery grey hairs.

*Eyes:* In two rows, the front row slightly recurved, the rear row distinctly recurved. The front row is a little shorter than the rear row. Ratio of eyes AME : ALE : PME : PLE = 4 : 4 : 5 : 5. The AME are separated from each other by half their individual diameter and from ALE by the same distance. The PME are separated from each other by half their individual diameter and from PLE by a space equal to four-fifths of the diameter of PME. The lateral eyes are separated from each other by a space equal to the diameter of PME. The eye space is wider than long in ratio 23 : 12, and occupies a little more than half the width of the front of the cephalothorax. The median ocular area is slightly longer than wide in ratio 12 : 11, and wider behind than in front in ratio 11 : 9. The space between

the eyes and immediately in rear of them is thickly clothed with soft recumbent silky grey hair directed towards the front and slightly overhanging the ALE. Projecting from among the hairs are a few short black bristles.

*Clypeus*: Moderately deep, the distance from its front edge to the AME is equal to one and a quarter times the diameter of the latter. It is clothed with grey silky hairs and a row of about eighteen black bristles along the front edge.

*Legs*: 4, 1, 2, 3. Brown, clothed with silky grey recumbent hairs intermingled with small black hairs and bristles. A few erect white hairs project from the legs. The first, second, and third metatarsi scopulate to base, the fourth scopulate near the apex, the scopula gradually becoming thinner towards the base. All tarsi scopulate to base. Trichobothria are present on all tarsi, metatarsi, and tibiae. There is a chitinous rim at the apex of the metatarsi. Tarsal claws two, each armed with a row of six or seven teeth. The trochanters are strongly notched as in the *Lygosidae*.

*Spines*: *First leg*. Femur—dorsal 1-1-1, prolateral 1-1-1, retrolateral 1-1-1-1, ventral 0. Patella 0. Tibia—dorsal 0, prolateral 1-1, retrolateral 1-1, ventral 2-2-2. Metatarsus—2 long spines on ventral surface near the base, elsewhere 0. *Second leg*. Femur—dorsal 1-1-1, prolateral 1-1-1-1, retrolateral 1-1-1-1, ventral 0. Patella 0. Tibia—dorsal 0, prolateral 1-1, retrolateral 1-1, ventral 2-2-2. Metatarsus—ventral 2 long spines near base, elsewhere 0. *Third leg*. Femur—dorsal 1-1-1, prolateral 1-1-1-1-1, retrolateral 1-1-1-1, ventral 0. Patella 0. Tibia—dorsal 1 in middle, prolateral 1-1, retrolateral 1-1, ventral 2-2-2. Metatarsus—dorsal 1 small spine near base, prolateral 1-1, retrolateral 1-1-1, ventral 2 near base 1 small spine at apex. *Fourth leg*. Femur—dorsal 1-1-1, prolateral 1-1-1 close together near base and 1 small spine near apex, retrolateral 1-1 near apex, ventral 0. Patella 0. Tibia—dorsal 2-1-2, prolateral 1-1, retrolateral 1-1, ventral 2-2-2. Metatarsus—dorsal 1-1-1-2, prolateral 1-1-1-1, retrolateral 1-1-1, ventral 2-2-2. *Palpi*. Femur—dorsal 1-1 and 2 close together near apex, prolateral 1 near apex, retrolateral 1 near apex, ventral 0. Patella—dorsal 1 at apex, prolateral 1, retrolateral 0, ventral 0. Tibia—dorsal 0, prolateral 3, retrolateral 0, ventral 0. Tarsus 0.

*Palpi*: Femur, patella, and tibia light brown, clothed with grey silky hairs and a few black bristles. Tarsus very large and nearly black; its retrolateral edge is reflexed



producing a longitudinal groove on the dorsal surface. On the retrolateral side the tibia is armed with a large flat apophysis, which ends in a point. The apophysis projects almost at right angles to the tibia and is nearly equal to it in length. The copulatory apparatus is shown in Text Figure 17. The embolus is very long and in the unexpanded

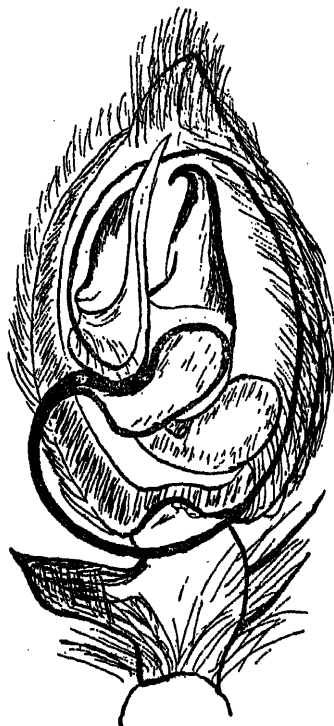


Fig 17. *Miturga velox*, sp. nov.  
Right palpus of male. Ventral view.

condition it originates on the retrolateral side of the alveolus, curves round past the apex of the tibia, makes an almost complete turn round the margin of the alveolus, and then bends sharply towards the apex of the segment. Its extremity lies along a white membranous conductor.

*Falces*: Black in front, clothed with white silky hairs and coarse black hairs. A light brown condyle on the side at the base. The fang moderately long and well curved. The retromargin of the furrow is armed with two teeth, while the promargin is provided with three teeth and a fringe

of long grey barbed hairs. There is also a single hair of the same nature near the base of the fang on the retroside.

*Maxillæ*: Apical half black, clothed with a few black bristles. The basal half is marked with three longitudinal light brown patches separated by two black stripes which extend into the black apical half. There are a few short black bristles along the black stripes but elsewhere the light brown patches are bare. The outer and inner margins are strongly convex. A light scopula clothes the upper half of the inner margin and forms a tuft at the uppermost angle. (Text Figure 18.)

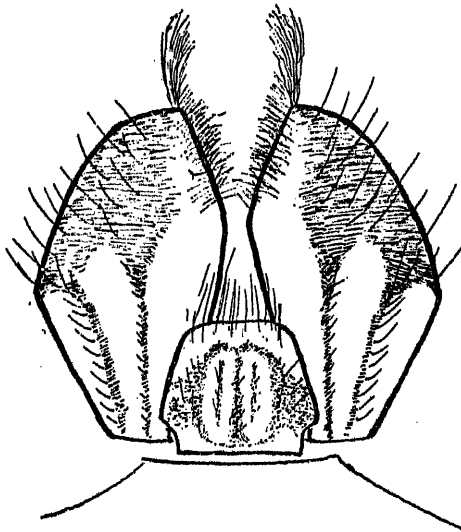


Fig. 18. *Miturga velox*, sp. nov.  
Labium and maxillæ in the male.

*Labium*: As wide as it is long and a little more than one-third of the length of the maxillæ. It is truncate in front and narrower than in rear. Colour light brown marked with a dark brown pattern as shown in Text Figure 18. Clothed with long black bristles in front and a few small bristles on the surface.

*Sternum*: Shield shape, slightly longer than broad in ratio 14 : 13. Light brown, clothed with coarse black bristle-like hairs and short fine black hairs. Coxæ concolorous with the sternum. The fourth pair of coxæ are contiguous in rear of the sternum.

*Abdomen:* Ovate; the dorsal surface is a light brownish colour, speckled with small black spots and marked with four pairs of dirty white spots down the mid-dorsal line. The clothing consists of black hairs intermingled with grey hairs. The ventral surface is clothed with black hairs and marked with four longitudinal lines composed of irregular nearly contiguous white spots. A dark shield-shaped area in front of the epigastric furrow is marked with a pair of large and a pair of small white spots. The lung covers are brown. Sides are black speckled with white. Tracheal spiracle near spinnerets.

*Spinnerets:* Brown, clothed with black hairs. Anterior pair subconical and shorter than the posterior pair; apical joint small and dome shaped. The posterior pair two jointed, the basal point being slightly longer than the apical joint in ratio 7 : 5. Middle pair small and cylindrical.

*Locality:* Trevallyn, Launceston. 4th September, 1929.

*Field Notes:* During September the males are found lurking in pieces of rolled bark on the ground, and under stones.

*Female.* Measurements in millimetres.

Total Length . . . . .	13.0
Length of Cephalothorax . . . . .	6.0
Width of Cephalothorax . . . . .	4.6
Length of Abdomen . . . . .	8.0
Width of Abdomen . . . . .	4.7

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Leg.	Femur.	Patella.	Tibia.	Metatarsus.	Tarsus.	Total.
1	4.35	2.43	3.48	2.90	1.85	15.01
2	4.11	2.37	3.19	2.84	1.74	14.25
3	3.77	2.20	2.90	2.72	1.62	13.21
4	5.51	2.37	4.06	4.75	2.03	18.72
Palpi	2.03	1.16	1.16	—	2.14	6.49

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Width of first patella at the "knee" 0.812 mm. Tibial Index 14.

Width of fourth patella at the "knee" 0.870 mm. Tibial Index 13.

*Cephalothorax:* Marked with patches of dark brown and light brown; clothed with black hairs intermingled with

grey hairs. Median depression long and deep, its anterior end is about three-fifths of the length of the cephalothorax from the front. It is marked by a Y-shaped patch of dark brown. In rear of the depression there is a patch of light brown sloping under the front of the abdomen. Between and behind the eyes and at the sides of the head region there is a thick clothing of grey hairs, from which project several black bristles. Margin marked with patches of dark brown and fringed with short grey hairs.

*Eyes:* In two rows; front row slightly recurved, rear row distinctly recurved and longer than the front row. The eye-space occupies three-fifths of the width of the cephalothorax in the region of the eyes and is broader than long in ratio 31 : 15. The eyes are equal in size. The AME are separated from each other by a space equal to three-quarters of their individual diameter and from the ALE by half their individual diameter. The PME are separated from each other by a space equal to three-quarters of their individual diameter. The PLE are separated from the PME by a space equal to one and a half times their diameter and from the ALE by the same distance. The median ocular area is longer than wide in ratio 13 : 12 and wider in rear than in front in ratio 12 : 11.

*Clypeus:* Narrow, the distance from its front edge to AME being equal to the diameter of the latter. Clothed with a few black bristles and grey hairs.

*Legs:* 4, 1, 2, 3. Dark brown, clothed with black hairs and recumbent grey hairs. Coxæ reddish brown. All tarsi and metatarsi scopulate to base, and a slight scopula on the prolateral side of the first and second tibiae near the apex. Trichobothria on all tarsi, metatarsi, and tibiae. Trochanters notched. Tarsal claws two, short, curved, and provided with three or four teeth.

*Palpi:* Colour and clothing like that of the legs. Spines on tarsus long. Single tarsal claw armed with three or four teeth.

*Spines:* *First leg.* Femur—dorsal 1-1, prolateral 1-1, retrolateral 1-1, ventral 0. Patella 0. Tibia—ventral 2-2-2, elsewhere 0. Metatarsus—ventral 2 near base, elsewhere 0. *Second leg.* Femur—dorsal 1-1, prolateral 1-1-1-1, retrolateral 1-1, ventral 0. Patella 0. Tibia—ventral 2-2-2, elsewhere 0. Metatarsus—ventral 2 near base, elsewhere 0. *Third leg.* Femur—dorsal 1-1-1, prolateral 1-1-1-1, retro-

lateral 1-1-1-1, ventral 0. Tibia—dorsal 1, prolateral 1-1, retrolateral 1-1, ventral 2-2-2. Metatarsus—dorsal 0, prolateral 1-1-1, retrolateral 1-1, ventral 2 near base and 1 small spine near apex. *Fourth leg.* Femur—dorsal 1-1-1, prolateral 1-1-1, retrolateral 1 near apex, ventral 0. Patella 0. Tibia—dorsal 1-1, prolateral 1-1, retrolateral 1-1, ventral 2-2-2. Metatarsus—dorsal 0, prolateral 1-2-2, retrolateral 2-2-2, ventral 2-2-1. *Palpi.* Femur—dorsal 1-1 and 2 close together near apex, prolateral 1 near apex, retrolateral 1 near apex, ventral 0. Patella—dorsal 1-1 bristles, prolateral 1, elsewhere 0. Tibia—dorsal 0, prolateral 2-1, retrolateral 1-1, ventral 0. Tarsus—dorsal 2 near base, prolateral 1-1, retrolateral 1-1, ventral 0.

*Falces:* Black, clothed in front with black bristles and grey hairs near the base, geniculate, provided with a brown condyle at the base on the side. Fang moderately long. Promargin of furrow armed with three teeth and fringed with long barbed grey hairs. Retromargin armed with two teeth, and furnished with a single long barbed grey hair near base of fang.

*Maxillæ:* Rounded in front, convex on inner and outer sides, and like those of the male short and wide, the ratio of length to width being 5 : 3. Colour black marked on the basal half with three longitudinal brown patches as in male. (See Text Figure 18.) Clothed with black bristles on the black areas, the brown patches glabrous. Inner edge furnished with a dark grey scopula on the upper half.

*Labium:* Oval, truncate in front, longer than wide in ratio 15 : 13, shaped as in the male. Clothed with a few long black bristles in front. Sides excavated in basal third.

*Sternum:* Oval, truncate in front, longer than broad in ratio 8 : 7. Dark brown in centre, lighter brown round the margin. Clothed with black bristles. Margin angulate between coxæ. The fourth pair of coxæ contiguous in rear of sternum.

*Abdomen:* Black marked with fawn spots. Clothed with black hairs and grey hairs. Seven pairs of whitish spots, clothed with white hairs, on the rear two-thirds of the dorsum. The spots decrease in size towards the rear. Sides clothed with black hairs and marked with rows of small white spots. Ventral surface black, clothed with black hairs

and marked with four longitudinal white lines composed of nearly contiguous white spots clothed with white hairs; the lines converge towards the spinnerets. Epigynum brown and shaped as shown in Text Figure 19.

*Spinnerets*: Resemble those of the male.

*Locality*: Punch Bowl, Launceston. 19th November, 1927.

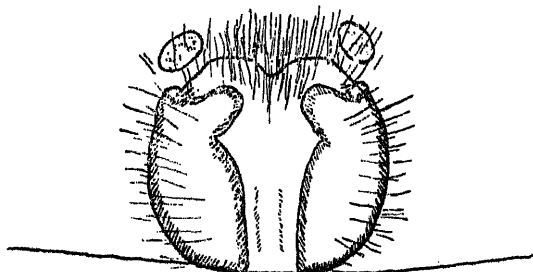


Fig. 19. *Miturga velox*, sp. nov.  
Epigynum of female.

*Field Notes*: During November the female is found guarding her egg sac in an oval nest built on the under surface of a stone. The nest is made of strong pale yellow silk, which is so thinly woven that the walls of the nest present a lace-like appearance. The outside of the nest is sometimes decorated with dry leaves, twigs, bits of earth, etc. Its long diameter is about 35 mm. and its short diameter 25 mm. in length. The egg sac is 12 mm. in diameter, plano-convex almost hemispherical in shape. It is made of white silk and attached to the top of the nest by ten little silken points placed at regular intervals round the edge of the flat side of the sac. (See Plate XXV., Figure 13.)

This spider is fairly common, and like *Miturga agelenina*, Simon, it favours sunny situations which are lightly timbered. Besides occurring round Launceston it is found at Fingal, Woodsdale, and Forth Falls.

*Observations*: The only spiders belonging to the genus *Miturga* previously recorded from Tasmania are *Miturga agelenina*, Simon, and the doubtful *Miturga necatrix*, Walck. (6) The latter species was originally placed in the genus *Clubiona*, but Simon (7) thinks that it is probably a species of *Miturga*. Walckenaer's description is so brief that it is difficult to recognise the spider from it. The species

described in the present paper are easily distinguished by the shape of the epigynum in the females and by the general appearance of the spiders as shown in the several Plates.

*Type specimens* of spiders described in this paper will be placed in the Queen Victoria Museum, Launceston.

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- (4) H. Hogg. P.Z.S., Vol. II., 1902, p. 140.
- (5) E. Simon. *Die Fauna Südwest-Australiens*, Bd II., 1909, p. 172.
- (6) C. Walckenaer. *Hist. Nat. des Ins.*, Apt. I., 1837, p. 597.
- (7) E. Simon. *Histoire Naturelle des Araignées*, T. II., 1897, p. 129.

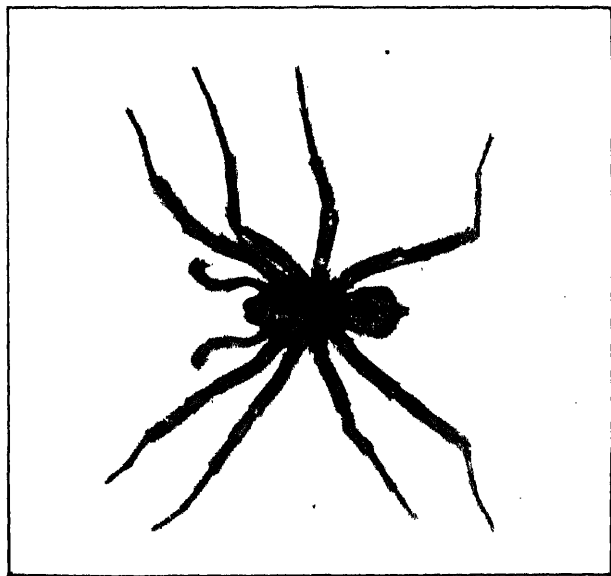


Fig 1 *Anane pera*, sp. nov.  
Male.

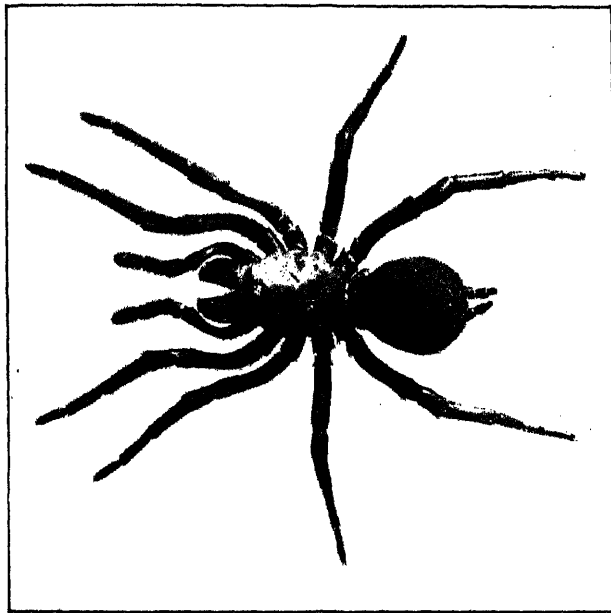


Fig. 2. *Anane pera*, sp. nov.  
Female.





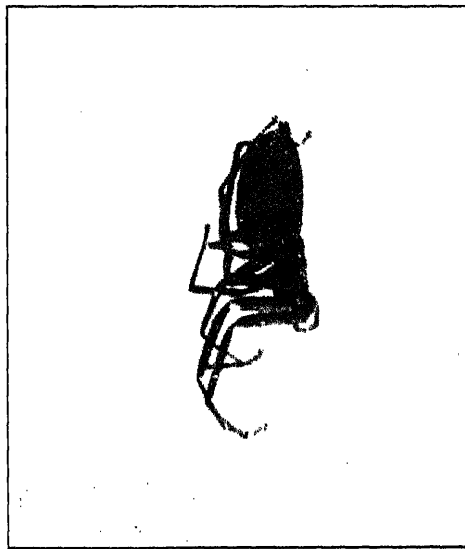


Fig. 3. *Tasmanonops alipes*, *gen. et sp. nov.*  
Female.

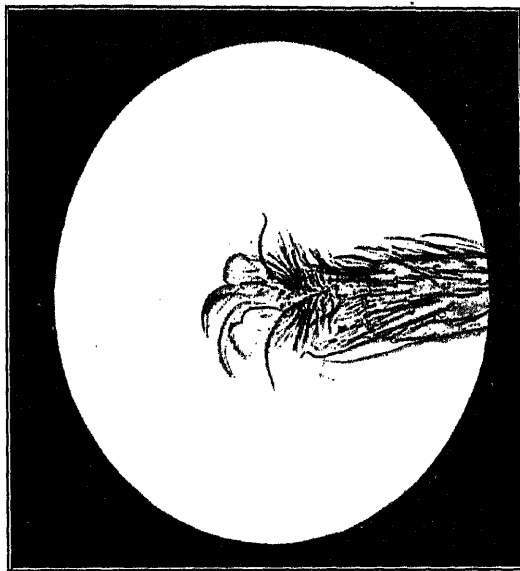


Fig. 4. *Tasmanonops alipes*, *gen. et sp. nov.*  
Photomicrograph of tarsal claws and onychium.



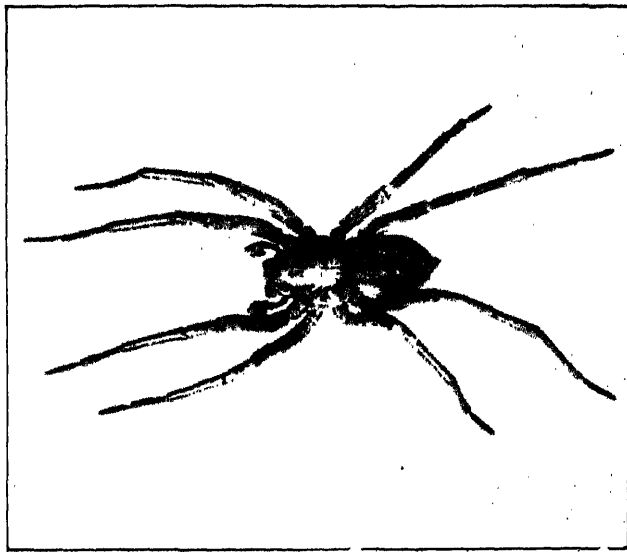


Fig. 5. *Miturga agelenina*, Simon.  
Male.

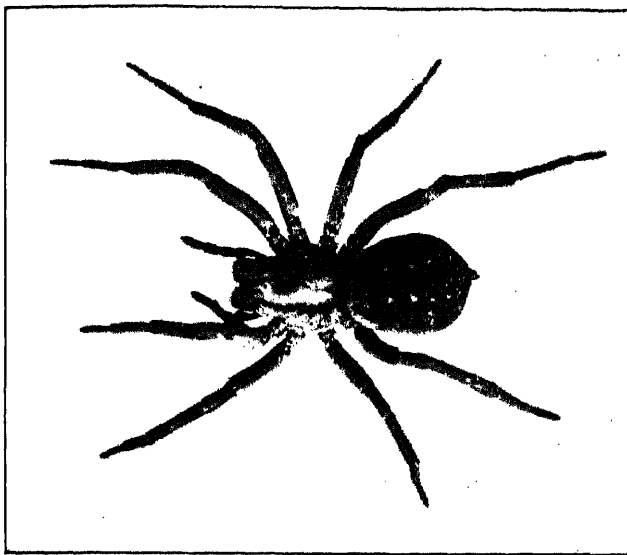


Fig. 6. *Miturga agelenina*, Simon.  
Female.





Fig. 7. *Milurga agelenina*, Simon.  
Nest on underside of a stone.



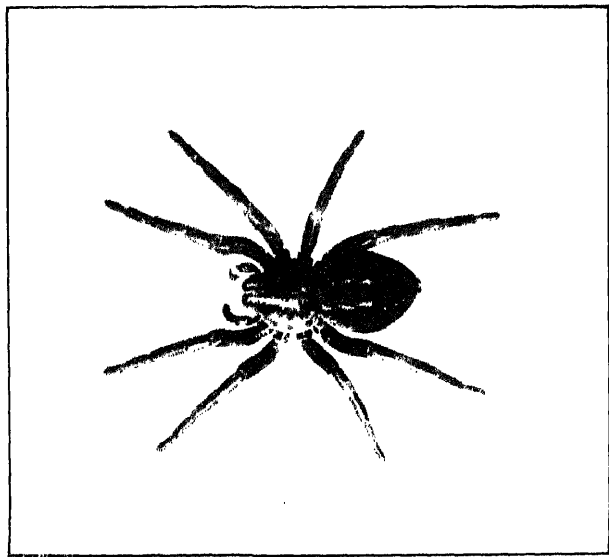


Fig. 8. *Miturga albopunctata*, sp. nov.  
Dorsal view of female.

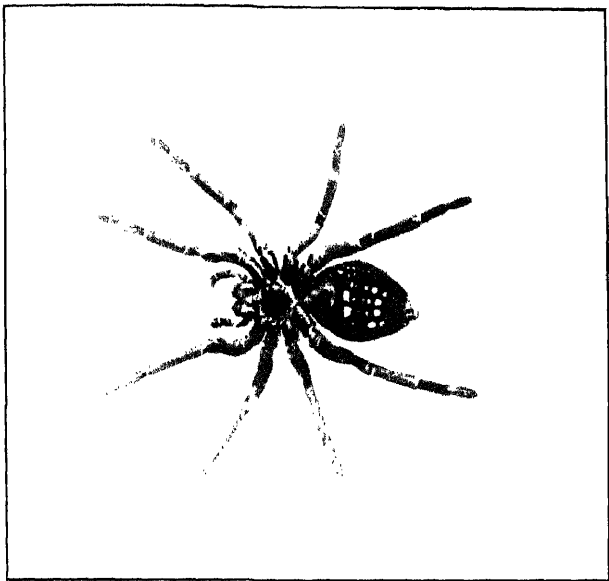


Fig. 9. *Miturga albopunctata*, sp. nov.  
Ventral view of female.





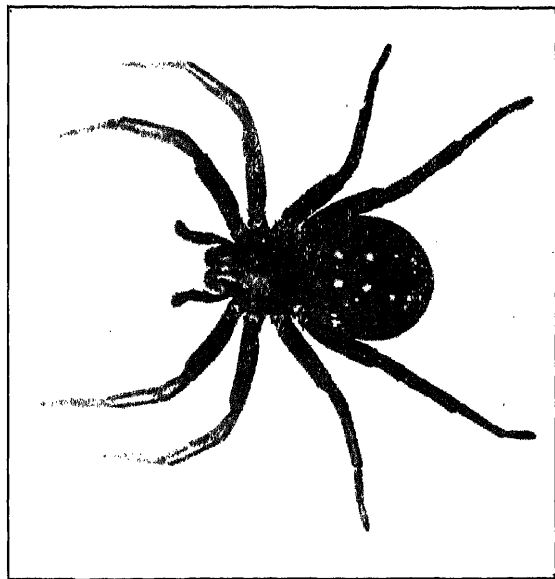


Fig. 10. *Miturga splendens*, sp. nov.  
Dorsal view of female.

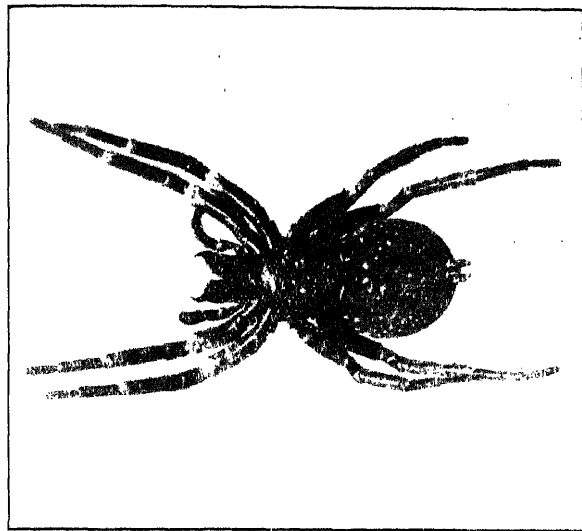


Fig. 11. *Miturga splendens*, sp. nov.  
Ventral view of female.



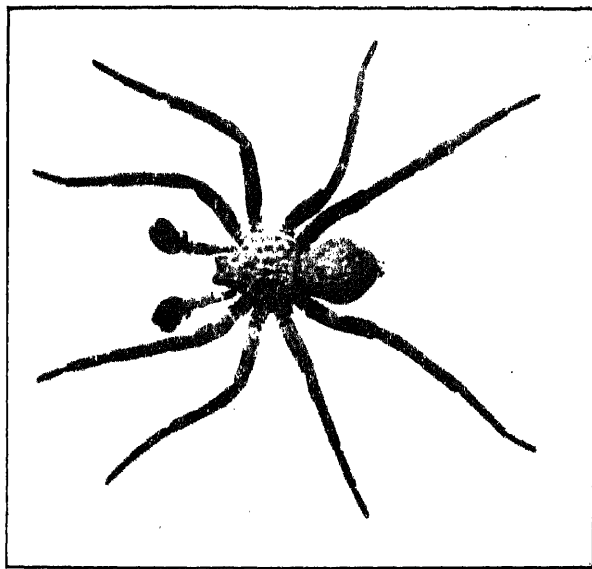


Fig. 12. *Miturga velox*, sp. nov.  
Male.



Fig. 13. *Miturga velox*, sp. nov.  
Female in nest guarding egg sac. Side of nest cut open.



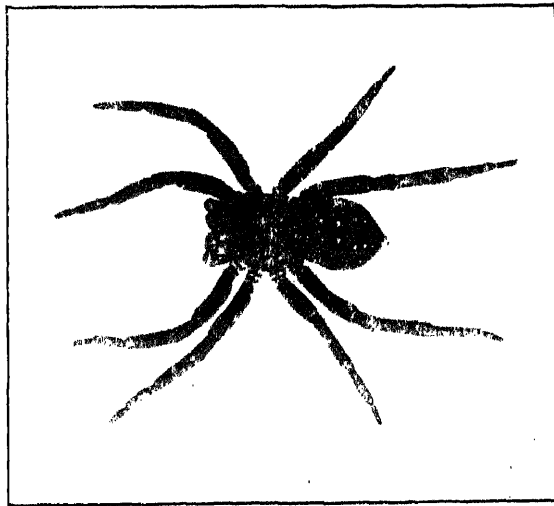


Fig. 14. *Miturga velox*, sp. nov.  
Dorsal view of female.

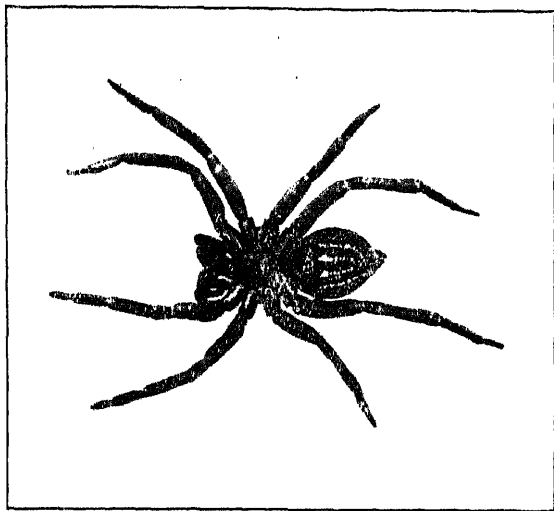


Fig. 15. *Miturga velox*, sp. nov.  
Ventral view of female.



## ON TWO TASMANIAN CRANIA (IMMATURE).

By

W. L. CROWTHER, D.S.O., M.B.

(Read 12th November, 1928\*.)

Plates XXVII.-XXIX.

## INTRODUCTION.

In describing these two crania I am influenced by the comparative rarity of such specimens, and the opportunity, now offered, of comparison with the adult Crania in the large collection of the Tasmanian Museum.

There remain for description of this extinct race the Crania of only eight children (of which one is of doubtful authenticity), (1899, p. 191).

The Crania under consideration are as follows:—

A. Cranium of a child of about 6 years or a little more, with the Mandible *in situ*. This was found by Dr. Inglis Clark and myself about Christmas, 1908, at Oyster Cove. Here the last 30-40 of the now extinct race were interred in a small cemetery adjacent to the Government Station, in which they lived. Burial had taken place in a coffin of hardwood (Blue Gum) at least 60 years before. When found the coffin had been distorted by the pressure of the earth, and the Cranium and long bones infiltrated with a variety of Peaty root.

Berry and Robertson (1909) did not take a tracing of this specimen when they described the remainder of the Crania in my collection.

B. The Cranium of a child of 6-7 years discovered by Mrs. R. W. Legge, on the West Coast of Tasmania, in the summer of 1927.

This skull is in a very fine state of preservation, but the Mandible is wanting. When found it was lying on the clay pan of a large sand blow, and no trace was found of any other human bones.

---

\*Originally read at the Hobart Meeting of the A.A.A.S., Hobart, January, 1928.



The Mandible very possibly may have been carried attached around the neck (1899, p. 64) or in a skin bag (1924) by one or other of the parents. On the other hand, the skull itself may have been carried about in the same manner. It was found lying on its side, on the slope of the "blow."

It will be of interest to see to what extent the features, that are regarded as typical of the Adult Tasmanian Cranium, are present in these immature types.

Topinard (1899, p. 197), in describing the specimens in the Paris collection, considers the following features to be typical of the Tasmanian type and of value in differentiating them from the Australian and other races.

These features are in order:

- (1) The Globular Form.
- (2) The Cranium is Sub-Dolichocephalic, without any notable transverse depression at the rise of the Forehead.
- (3) The skull broadens rapidly from before backwards, with rounded sides and large Conical Parietal Bosses.
- (4) The Carinate or Keeled appearance of the vault.
- (5) A recession of the Posterior Parietal position of the skull.

It will be of interest to see to what degree these characteristics are found in the two skulls under consideration.

#### SKULL A.

Child 6-7 years of age, from its fragility, probably a Female. When found some of the short bronze-coloured rings of hair were still attached to the scalp.

The body seems to have been placed on its left side (my memory will not serve me in recalling the exact details), as the skull is flattened over the Fronto-Temporal regions with disintegration of the bone and replacement by fibrous root.

In spite of this, however, the skull retains sufficient of its characteristics to be of great interest.

*Norma Facialis.*—The left side of the face as a whole is flattened and displaced a little backward, with the Temporal Fossa, Orbit, Malar bone, and Superior Maxilla wanting or replaced by fibrous root.

The Glabella is not pronounced, nor is the Superciliary Ridge of the right side.

There is no typical transverse depression from which the forehead may arise. The nasal bones are wanting with consequent loss of definition of the nasal aperture.

The right side of the face is, however, fairly complete and the Orbit well defined except on the mesial surface.

It is of much interest to note that the Orbit is almost quadrilateral, with little difference between its height and breadth (exact measurements cannot be taken).

This is of marked contrast to the Orbit of the Adult Tasmanian, which is typically of markedly greater breadth than height (1899, p. 214). The index for 6 males being 76.6, and for 2 females 81.

*Norma Lateralis* (Plate XXVII.).—The most interesting aspect of this specimen. The Mandible is seen in position, and the teeth (the Dentine of which has split and exposed the pulp) are *in situ*.

The Molars and Premolars of the Upper and Lower Maxillæ are approximated, with a gap filled with root fibre showing where the Incisors are missing. The Inferior Maxilla has not been separated from the skull, and the roots replacing the soft tissues are holding it accurately in the position it would have occupied during life.

The whole lower portion of the face projects forward, and the impression given is one of marked Prognathism (see Plate XXVII.).

The Lateral aspect of the Temporal Region is rounded, and the Parietal Eminence is well marked. The Posterior Parietal Region also shows recession.

*Norma Verticalis*.—The R. and L. Half Sections, owing to pressure, are very dissimilar, and the former alone is taken into consideration.

Here following the rise of the forehead is a narrowing transversely, in marked contrast to the exceptional development of the Right Parietal area towards the Parietal Eminence.

The Median Groove is well marked, indeed, markedly so, between the two Parietal Eminences. A depression, or rather a flattening, may be seen between the latter point and the Median Line.

The skull could not be described as Carinate.

*Teeth*.—The 6 year Molar is erupted, and the 12 year Molars may be seen *in situ* in the Superior and Inferior Maxillæ of the Right side.

The 2 Premolars, although shattered, are present. The remainder of the Teeth have disintegrated or dropped out.

## CRANIUM B.

(Plates XXVIII. and XXIX.).

The skull is that of a child of 7-10 years of age, probably a male. The R. aspect of this Cranium shows some loss of the outer Table of the Parietal Bone and is lightly scorched by fire about the Parieto-Occipital Area, the Temporal Fossa, and above and below the Orbit.

This is due, I think, to a grass fire rather than any attempt at Incineration.

*Norma Facialis* (Plate XXIX.).—Little or no protuberance of the Glabella or Superciliary Ridges are to be made out. The Supra-Orbital Notch is wide and shallow.

The Nasal Bones are not projected forward and upward to the extent that is seen in the adult. The Nasal Spine is well marked, no Metopism. The Orbits are of great interest, their measurements being:—

Right Orbit.

Breadth 3.3 = cm.

Height 3.4 =

Left Orbit.

Breadth 3.3 = c.m.

Height 3.3 =

This Cranium is therefore in agreement with Specimen A., in that instead of the preponderance of Orbital Breadth over Height of the Typical Adult, we have in both cases the Orbital Height almost equal to its Breadth.

In this Area there is no suggestion of the massive overhanging eyebrows of the Adult.

The face, as a whole, does not appear to be as Prognathous as it is in Specimen A.

*Norma Lateralis* (Plate XXVII.).—The Temporal Region shows some rounding, and on each side a well-marked Lower Temporal Ridge.

The Zygomatic Arch of the Left side is missing. The Post-Parietal Area of each side recedes typically.

*Norma Verticalis*.—The Forehead is broad and with very little narrowing posterior to the external Angular processes of the Frontal Bones.



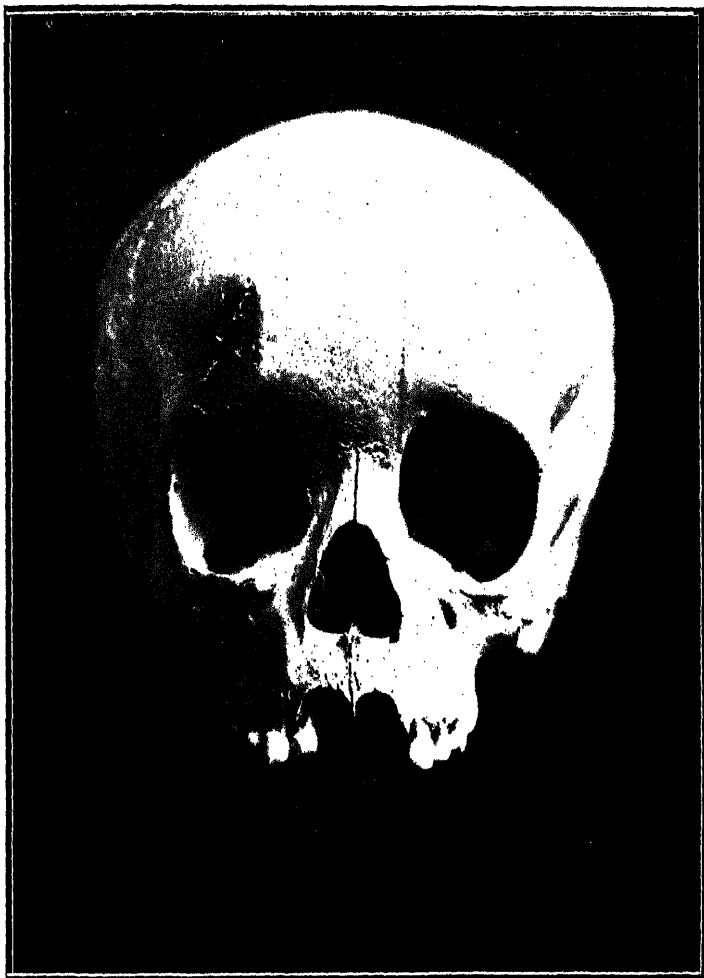
CRANIUM A.  
Tasmanian Child, 6-7 years.





CRANIUM B.  
Tasmanian Child, 7-10 years.





CRANIUM B.  
Tasmanian Child, 7-10 years.





The shape is typically Pentagonal with marked development of the Parietal Eminences.

The vault as a whole appears to be flattened rather than of the typically Carinate Form.

*Teeth.*—On both sides the First Incisor is missing. On the right side the Second Incisor of the Primary Dentition is still *in situ*. The Canines with First and Second Premolars remain, and show a considerable amount of even wear. The First Molars are fully erupted, show four Cusps, and have been little used; the Second Molars are in position unerupted.

The Palate is deep, and the Antero Posterior length greater than the Transverse. The general configuration of the Palatal Area is oblong rather than horseshoe-shaped, as remarked by Scott and McClinton in the examples they describe (1925, p. 96).

*Conclusion.*—Generally, it may be said that in their Physical Characters both these immature Crania conform to the Adult types of their race, and could be distinguished by their Tasmanian characteristics. Neither, however, shows the very typical carination of the Vault of the Cranium. The Facial Features are worthy of detailed attention, in a larger series of skulls; as it seems that in early life a marked width of the face at the expense of its Height is not pronounced.

It appears, too, that the Orbit and Nasal Apertures (possibly, too, the Palatal Area) as a result of growth and mastication tend to expand laterally, and with the normal heavy development of the Glabella and Supra-Orbital Ridges give rise to the Facial characteristics of the Adult Skull as we recognise them.

#### ACKNOWLEDGMENT.

My warm thanks are due to Mrs. R. W. Legge, who, as stated, found Specimen B., for her permission to describe it.

Also to Mr. Angus Hean, B.D.Sc., who was greatly interested in the Dentition of both Crania.

#### REFERENCES.

- 1899—H. Ling Roth—*Aborigines of Tas.*, 2nd Ed.  
 1909—Berry and Robertson—*Trans. Roy. Soc. Vic.*, Vol V., pt. 1.  
 1924—R. Palleine—*Trans. Roy. Soc. of S.A.*, Vol. 48.  
 1925—Scott and McClinton—*Pap. and Proc. Roy. Soc. Tas.*, 1925.

# THE ROYAL SOCIETY OF TASMANIA

## ABSTRACT OF PROCEEDINGS

1929.

11th FEBRUARY, 1929.

### *Special Meeting.*

*Farewell to Major L. F. Giblin, D.S.O.*

A special meeting was held on the 11th February, 1929, at the Society's Rooms, Tasmanian Museum, Hobart, the President of the Society, Sir James O'Grady, K.C.M.G., presiding.

The Chairman of the Council (Dr. A. H. Clarke, M.R.C.S., L.R.C.P.) stated that the meeting had been called in order to bid farewell to Major L. F. Giblin, who had been appointed Ritchie Professor of Economics at the University of Melbourne. The Chairman drew attention to the work done on behalf of the Society by Major Giblin, and also to his work on behalf of the State and the Commonwealth as a whole.

Major Giblin gave an address, "Beetles and Kings, A Programme for Tasmania," after which a vote of thanks was moved by His Excellency and seconded by Dr. A. H. Clarke. At the conclusion of the meeting a conversazione was held in the Art Gallery.

14th FEBRUARY, 1929.

### *Special Meeting.*

A special meeting was held on 14th February at the Society's Rooms, Tasmanian Museum, Hobart, the Chairman of the Council, Dr. A. H. Clarke, presiding.

Lieutenant-Commander Moyes delivered an illustrated lecture on Antarctic Exploration.

11th MARCH, 1929.

### *Annual Meeting.*

The Annual Meeting was held on the 11th March, 1929, at the Society's Rooms, Tasmanian Museum, Hobart, Mr. L. Rodway, C.M.G., Vice-President, presiding.

The Annual Reports and Financial Statement for 1928 were read and adopted.

The following were elected members of the Council for 1929:—Dr. A. H. Clarke, Dr. W. L. Crowther, Mr. J. A. Johnson, W. H. Clemes, Mr. A. V. Giblin, Mr. A. N. Lewis, Mr. E. E. Unwin, Mr. L. Rodway, Mr. F. E. Ward, Mr. C. E. Lord (*ex officio*).

Mr. W. E. Taylor was elected Honorary Auditor.

*Lecture.*

Mr. F. E. Ward, Director of Agriculture, delivered an illustrated lecture on the Agricultural Department of Tasmania.

8th APRIL, 1929.

The monthly meeting was held at the Society's Rooms, Tasmanian Museum, Dr. A. H. Clarke presiding.

The following were elected members:—Messrs. G. Chapman, Q. Henderson, G. A. Jaques, N. Johnson, J. F. N. Murray, H. Pearce, D. W. Read, M. Roche, G. White, Major Thirkell, Miss D. Baudinet.

*Lecture.*

The Honourable Angus Butler delivered an illustrated lecture on a motor-car trip from Nigeria to Khartoum.

13th MAY, 1929.

The monthly meeting was held at the Society's Rooms, Tasmanian Museum, Dr. A. H. Clarke presiding.

*Papers.*

"Flinders, Baudin, and Brown at Encounter Bay." By R. W. Giblin, F.R.G.S.

"Notes on the Genus *Poria*." By L. Rodway and J. B. Cleland.

*Lecture.*

Mr. Clive Lord delivered an illustrated lecture on the Exploration of Flinders in Tasmanian Waters.

10th JUNE, 1929.

The monthly meeting was held at the Society's Rooms, Tasmanian Museum, Mr. L. Rodway, C.M.G., presiding.

*Papers.*

"Robert Brown at Port Dalrymple." By R. W. Giblin,  
F.R.G.S.

"Definition of a New Fossil Chiton." By E. Ashby,  
F.L.S.

"Additions to the Catalogue of Tasmanian Mollusca."  
By Dr. P. Ansell Robin.

*Lecture.*

Mr. A. N. Lewis delivered an illustrated lecture on  
"Geology in Relation to Tracts of Agricultural Lands."

8th JULY, 1929.

The monthly meeting was held at the Society's Rooms,  
Tasmanian Museum, Mr. L. Rodway, C.M.G., presiding.

The following were elected members of the Society:—  
Mrs. E. H. Linton, Mr. V. I. Chambers, Mr. C. G. Stephens.

The following resolution was adopted:—

"That this Society places on record its appreciation  
of and gratitude for the pre-eminent services  
rendered by Professor L. F. Giblin, D.S.O.,  
M.C., M.A., in the cause of the advancement of  
knowledge in Tasmania."

*Lecture.*

A series of cinematograph films showing the production  
of paper, examples of relativity, &c., were shown.

12th AUGUST, 1929.

The monthly meeting was held at the Society's Rooms,  
Tasmanian Museum, Mr. L. Rodway, C.M.G., presiding.

A motion of condolence was passed in reference to the  
death of Sir Baldwin Spencer, K.C.M.G., honorary member  
of the Society, who had died whilst engaged upon anthro-  
pological research in South America.

*Papers.*

"Magic Stones of the Tribes east and north-east of  
Lake Eyre." By G. Aiston.

"Method of Mounting Stone Tools on Koondi. Tribes  
east and north-east of Lake Eyre." By G. Aiston.

"Tasmanian Stone Culture, Spoke-shavers, Borers, and  
Chipping-tools." By R. W. Legge.

9th SEPTEMBER, 1929.

The monthly meeting was held at the Society's Rooms, Tasmanian Museum, Mr. L. Rodway, C.M.G., presiding.

Mr. A. J. H. Thomas was elected a member of the Society.

*Lecture.*

Mr. F. Smithies delivered an illustrated lecture on "The Wild Heart of Tasmania."

14th OCTOBER, 1929.

The monthly meeting was held at the Society's Rooms, Tasmanian Museum, His Excellency Sir James O'Grady presiding.

Mr. P. F. C. Mattingley and Mr. W. F. Grace-Calvert were elected members of the Society.

*The R. M. Johnston Memorial Lecture.*

Dr. R. J. Tillyard, F.R.S., delivered the third R. M. Johnston Memorial Lecture, his title being "The Biological Control of Noxious Weeds."

*Conversazione.*

At the conclusion of the meeting, a conversazione was held in the Art Gallery.

11th NOVEMBER, 1929.

The monthly meeting was held at the Society's Rooms, Tasmanian Museum, Mr. L. Rodway, C.M.G., presiding.

Mr. L. H. Giles was elected a member of the Society.

*Exhibition of Early Records.*

The Society's collection of early historical records, including a large number of water colours of historical interest, were placed on exhibition.

# THE ROYAL SOCIETY OF TASMANIA

---

**Patron:**

HIS MAJESTY THE KING.

**President:**

HIS EXCELLENCY SIR JAMES O'GRADY, K.C.M.G.

**Vice-Presidents:**

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(Chairman)

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CLIVE LORD, F.L.S.

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- Mawson, Sir Douglas, Kt., O.B.E., B.E., D.Sc., F.R.S. Professor of Geology and Mineralogy, the University, Adelaide.
- Wood-Jones, Professor F., M.B., D.S., M.R.C.S., L.R.C.P., D.Sc., F.R.S. The University, Melbourne.
- Tillyard, R. J., M.A. Sc.D. (Cantab.), D.Sc., F.R.S., F.N.Z. Inst., F.L.S., F.G.S., F.E.S., C.M.Z.S. Chief of the Division of Economic Entomology, C.S.I.R., Canberra City, F.C.T.

### Corresponding Members:

- | Year of Election. |   |
|-------------------|---|
| 1901              | Benham, W. B., M.A., D.Sc., F.R.S., F.Z.S. Professor of Biology, University of Otago, Dunedin, N.Z. |
| 1892              | Bragg, Sir W. H., M.A., F.R.S. Director of the Royal Institution, Albemarle Street, London.         |
| 1901              | Chapman, Professor R. W., M.A., B.C.E. The University, Adelaide.                                    |
| 1923              | Pulleine, R., M.B. 163 North Terrace, Adelaide.   |
| 1902              | Smith, R. G., D.Sc. Linnean Hall, Linnean Society of N.S.W., 16 College Street, Sydney.             |
| 1892              | Thomson, Hon. G. M., M.L.C., F.L.S. 99 Eglinton Road, Dunedin, N.Z.                                 |
| 1901              | Wall, Professor A., M.A. Canterbury College, Christchurch, N.Z.                                     |

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- 1918 Avery, J. 52 Southerland Road, Annadale, Melbourne.
- 1908 Baker, H. D. American Consular Service, Washington.
- 1890 Foster, Lieutenant-Colonel Henry. "Merton Vale," Campbell Town.
- 1905 Grant, C. W. "High Peak," Huon Road.
- 1894 Mitchell, J. G. Parliament Street, Sandy Bay.
- 1896 Sprott, G., M.D. Town Hall, Hobart.



**Members:**

- Year of Election.**
- 1921 Anderson, G. M., M.D., C.M. Clare Street, New Town.
- 1923 Agnew, Miss K. Augusta Road, New Town.
- 1921 Allen, D. V., B.Sc. Launceston Technical School, Launceston.
- 1924 Allen, F. A. 13 Franklin Street, West Hobart.
- 1928 Allport, Henry. 111 Macquarie Street, Hobart.
- 1925 Ashbolt, Sir Alfred. "Lenna," Battery Point.
- 1926 Atkins, C. N., M.B., B.S., D.P.H. 145 Macquarie Street, Hobart.
- 1927 Atkinson, T. H. Department of Agriculture, 90 Cameron Street, Launceston.
- 1928 Avery, David. Geeveston, Tasmania.
- 1921 Baker, Hon. H. S., LL.M., D.S.O. Messrs. Finlay, Watchorn, Baker, and Turner, Murray Street, Hobart.
- 1927 Barnes, G. L. C/o Messrs. Giblin and Piesse, Hobart.
- 1921 Barr, J. Stoddart, M.D. (Glasgow). Lower Sandy Bay.
- 1926 Barrett, Rev. W. R. Christ College, Glebe, Hobart.
- 1929 Baudinet, Miss D. 336 Murray Street, Hobart.
- 1890 Beattie, J. W. 28 Jordan Hill Road, Hobart.
- 1918 Bellamy, H., J.P., M.Am.Soc. C.E., M.I.Mech.E., F.R. San. I. Government Hydraulic Engineer. Adelaide.
- 1924 Bennett, H. W., L.D.S., D.D.S. Brisbane Street, Launceston.
- 1903 Bennett, William H. Ashby, Ross.
- 1909 Blackman, A. E. 26 Warwick Street, Hobart.
- 1920 Blaikie, T. W. Practising School, Elizabeth Street, Hobart.
- 1927 Blake, Frank. Red Chapel Road, Lower Sandy Bay.
- 1918 Bowling, J. "Barrington," Tower Road, New Town.
- 1924 Booth, N. P. Messrs. Cadbury-Fry-Pascall Pty. Ltd., Claremont.
- 1925 Bowerman, Captain. Marine Board, Hobart.
- 1923 Breaden, J. C. 12 Waverley Avenue, New Town.
- 1917 Brettingham-Moore, E., M.B., Ch.M. Macquarie Street, Hobart.
- 1928 Brettingham-Moore, Mrs. E. Macquarie Street, Hobart.
- 1925 Brigden, Professor J. B., B.A. 8 Young Street, Sydney, N.S.W.

Year of  
Election.

- 1911 Brooks, G. V. Director of Education, Hobart.  
 1922 Brownell, C. C. 117 Hampden Road, Battery Point.  
 1907 Brownell, F. L. "Berwyn," Mercer Street, New Town.  
 1928 Buchanan, Howard. E.S. & A. Bank, Hobart.  
 1929 Burbury, A. W. Austin's Ferry.  
 1918 Burbury, Charles. "Brookside," Moonah.  
 1918 Burbury, Frederick. "Holly Park," Parattah.  
 1927 Butcher, M. G. 103 York Street, Sandy Bay.  
 1925 Butler, A. L. Lower Sandy Bay.  
 1923 Butler, Mrs. G. H. 30 Augusta Road, New Town.  
 1909 Butler, W. F. D., B.A., M.Sc., LL.B. Bishop Street,  
 New Town.  
 1924 Calver, C. W. 112 Brisbane Street, Launceston.  
 1920 Cane, F. B. 90 High Street, Sandy Bay.  
 1929 Chambers, V. I. 22 Murray Street, Hobart.  
 1929 Chapman, G. T. F. 212 Davey Street, Hobart.  
 1928 Chapman, Miss Joi. 212 Davey Street, Hobart.  
 1927 Cherry, P. J. Burnie.  
 1913 Chepmell, C. H. D. Clerk of the Legislative Council,  
 Hobart.  
 1920 Clark, W. I., M.B. Macquarie Street, Hobart.  
 1896 Clarke, A. H., M.R.C.S., L.R.C.P. Domain Cottage,  
 The Domain, Hobart.  
 1918 Clarke, T. W. H. "Quorn Hall," Campbell Town.  
 1910 Clemes, W. H., B.A., B.Sc. Clemes College, Hobart.  
 1922 Collier, J. D. A. The Librarian, Tasmanian Public  
 Library, Hobart.  
 1925 Coogan, W. Lord Street, Sandy Bay, Hobart.  
 1927 Cooper, S. G. 5 Main Road, New Town.  
 1929 Crace-Calvert, W. F. 32 View Street, Hobart.  
 1928 Cranstoun, Mrs. 6 Gregory Street, Sandy Bay.  
 1911 Crowther, W. L., D.S.O., M.B. Macquarie Street,  
 Hobart.  
 1917 Cullen, Rev. John. Macquarie Street, Hobart.  
 1918 Cummins, W. H., A.I.A.C. Manager, *The Mercury*  
 Office, Hobart.  
 1922 Davidson, R. Temple Chambers, Macquarie Street,  
 Hobart.  
 1927 Dallas, K. M. State High School, Launceston.  
 1924 Davies, G. B. 111 Patrick Street, Hobart.  
 1919 Davies, H. Warlow. 22 Augusta Road, New Town.  
 1923 Davis, Charles. Red Chapel Road, Lower Sandy  
 Bay.  
 1908 Dechaineux, L. Principal of the Technical College,  
 Hobart.

Year of  
Election.

- 1921 Dryden, M. S. 13 Hillside Crescent, Launceston.  
 1921 Eberhard, E. C. Charles Street, Launceston.  
 1919 Elliott, E. A., M.B., Ch.M. Main Road, New Town.  
 1921 Emmett, E. T. Director of the Tasmanian Government Tourist Bureau.  
 1921 Erwin, H. D. Hutchins School, Hobart.  
 1918 Evans, L. The Agricultural Department, Hobart.  
 1921 Eyre, H. Boys' Welfare School, Elizabeth Street, Hobart.  
 1902 Finlay, W. A. 11 Secheron Road, Hobart.  
 1918 Fletcher, C. E., M.A. 21 Stoke Street, New Town.  
 1928 Foley, J. C. Weather Bureau, Hobart.  
 1921 Forward, J. R. Mechanics' Institute, Launceston.  
 1921 Fox, Miss. Ladies' College, Launceston.  
 1918 Gatenby, R. L. Campbell Town.  
 1927 Gates, W. 41 Hunter Street, Hobart.  
 1927 Gellibrand, W. T. "Lachlan Vale," Ouse, Tasmania.  
 1927 Giblin, Dr. Arthur. Macquarie Street, Hobart.  
 1922 Giblin, A. V. King Street, Sandy Bay.  
 1908 Giblin, Major L. F., D.S.O., B.A. Ritchie Professor of Economics, the University, Melbourne.  
 1926 Giblin, R. W., F.R.G.S., F.R.C.I. 71 Harrington Gardens, London, S.W. 7, England.  
 1921 Giblin, Colonel W. W., C.B., V.D., M.R.C.S., L.R.C.P. Macquarie Street, Hobart.  
 1929 Giles, L. H. C/o N.C.R. Co., 80 Collins Street, Hobart.  
 1927 Gillies, C. L. Department of Agriculture, Hobart.  
 1923 Gorrings, J. A. Kempton, Tasmania.  
 1927 Grant, H. N. Tasmanian Club, Hobart.  
 1923 Green, Dr. A. W. 30 Parliament Street, Sandy Bay.  
 1929 Grueber, F. W. 71 Arthur Street, Hobart.  
 1929 Grueber, S. H. 29 Bishop Street, New Town.  
 1928 Gunn, Miss Isabel. Invercarron, Broadmarsh, Tasmania.  
 1924 Hall, E. L. 38 Lyttleton Street, Launceston.  
 1922 Halligan, G. H., F.G.S. "Uplands," Station Street, Pymble, N.S.W.  
 1918 Harrap, Lieutenant-Colonel G. Launceston.  
 1919 Hay, Rt. Rev. R. S., D.D. Bishop of Tasmania, Bishops court, Hobart.  
 1929 Henderson, Q. J. Mines Department, Hobart.  
 1924 Heritage, F. W. Collins Street, Hobart  
 1921 Heritage, J. E. Frederick Street, Launceston.

Year of  
Election.

- 1921 Heyward, F. J., F.R.V.I.A. 43 Lyttleton Street, Launceston.
- 1915 Hickman, V. V., B.A., B.Sc. Mulgrave Crescent, Launceston.
- 1914 Hitchcock, W. E. Storey's Creek, Avoca, Tasmania.
- 1918 Hogg, G. H., M.D., C.M. 37 Brisbane Street, Launceston.
- 1928 Holland, C. W. Agricultural Extension Service, Sorell, Tasmania.
- 1922 Hood, Captain F. W. Customs House, Hobart.
- 1928 Hudson, E. R. Department of Agriculture, Hobart.
- 1923 Hudspeth, W. H. "The Nook," Lower Sandy Bay.
- 1923 Hungerford, Mrs. "Hathaway House," Holebrook Place, Hobart.
- 1909 Hutchison, H. R. 1 Barrack Street, Hobart.
- 1898 Ireland, E. W. J., M.B., C.M. Macquarie Street, Hobart.
- 1919 Jackson, George A. 79 Collins Street, Hobart.
- 1929 Jaques, G. A. Union Bank, Hobart.
- 1906 Johnson, J. A., M.A. Training College, Hobart.
- 1929 Johnson, Norman. Tasmanian Club, Hobart.
- 1922 Johnson, W. R. Clemes College, Hobart.
- 1922 Johnston, J. R. Murray Street, Hobart.
- 1921 Judd, W., M.A. College Street, Launceston.
- 1911 Keene, E. H. D., M.A. Burnie.
- 1922 Kemp, Andrew. Stoke Street, New Town.
- 1922 Kennedy, J. 96 Montpelier Road, Hobart.
- 1922 Kennedy, Mrs. J. 96 Montpelier Road, Hobart.
- 1927 King, C. S. 12 Swanston Street, New Town.
- 1927 Kirby, E. R. 13 Mortyn Avenue, Hobart.
- 1918 Knight, C. F. L., B.Sc. Claremont.
- 1927 Knight, F. C. E. Claremont.
- 1919 Knight, H. W. National Mutual Buildings, Hobart.
- 1913 Knight, J. C. E. Claremont.
- 1924 Legge, R. W. Cullenswood, Tasmania.
- 1919 Lewis, A. N., M.C., LL.M. "Holebrook," Holebrook Place, Hobart.
- 1923 Lewis, Mrs. A. N. "Holebrook," Holebrook Place, Hobart.
- 1887 Lewis, Sir N. E., K.C.M.G., M.A., B.C.L., LL.B. Augusta Road, New Town.
- 1912 Lindon, L. H. "Waimu," Canice Road, Sandy Bay.
- 1926 Lindon, Mrs. L. H. "Waimu," Canice Road, Sandy Bay.

Year of  
Election.

- 1929 Linton, Mrs. E. H. "Meldreth," South Springfield,  
Tasmania.
- 1912 Lord, Clive E., F.L.S. Director of the Tasmanian  
Museum, Hobart.
- 1927 Lord, Graham H. Vacuum Oil Co., Hobart.
- 1921 Lord, Raymond. Proctor's Road, Queenborough.
- 1924 Lord, Ronald. Derwentwater Avenue, Sandy Bay.
- 1922 Low, H. M. "The Gables," Pottery Road, New Town.
- 1893 McAulay, Professor A., M.A. Lower Sandy Bay.
- 1923 McAulay, Professor A. L., Ph.D. The University,  
Hobart.
- 1921 McClinton, Dr. R. 70 St. John Street, Launceston.
- 1927 Mace, Miss V. E. "The Pottery," Bothwell.
- 1927 Macfarlane, Charles. State High School, Hobart.
- 1923 Macfarlane, Mrs. Charles. 3 Montagu Avenue, New  
Town.
- 1928 McElroy, J. D. 32 Bellevue Parade, New Town.
- 1919 Mackay, A. D. 26 High Street, Launceston.
- 1922 Macleod, Mrs. L. H. 67 High Street, Sandy Bay.
- 1918 Mansell, A. E. 53 Collins Street, Hobart.
- 1924 Marsh, James. "Ingomar," Patrick Street, Hobart.
- 1918 Martin, Brigadier-General W. Launceston.
- 1921 Masters, A. H. Forest Road, Trevallyn, Launceston.
- 1929 Mattingley, P. F. C. 36 Brisbane Street, Launceston.
- 1926 Meredith, David. Electrolytic Zinc Co., Risdon.
- 1927 Meredith, Mrs. D. 107 High Street, Sandy Bay.
- 1921 Meston, A. L. Ronald Street, Devonport.
- 1909 Millen, Senator J. Roxburgh, Newstead, Launceston.
- 1921 Miller, R. M. State High School, Launceston.
- 1911 Montgomery, R. B. 303 Davey Street, Hobart.
- 1927 Morris, J. M. The Union Bank, Hobart.
- 1928 Morris, Robert J. Liverpool Street, Hobart.
- 1927 Murdoch, George. Macquarie Street, Hobart.
- 1918 Murdoch, Honourable Thomas, M.L.C. 55 Montpelier  
Road, Hobart.
- 1929 Murray, J. F. N. Federal Taxation Department,  
Hobart.
- 1926 Murray, L. C. 124 Warwick Street, Hobart.
- 1921 Muschamp, Rev. E. Holy Trinity Rectory, Launceston.
- 1928 Nelson, Alexander, Ph.D., B.Sc.
- 1924 Newall, A. P. Charles Street, Moonah.
- 1882 Nicholas, G. C. "Cawood," Ouse.
- 1918 Nicholls, Sir Herbert, K.C.M.G., Chief Justice of Tas-  
mania. Pillinger Street, Sandy Bay.

Year of  
Election.

- 1910 Nicholls, H. M. Department of Agriculture, Hobart.  
 1921 Nye, P. B., M.Sc., B.M.E. Geological Survey Office,  
 Hobart.  
 1917 Oldham, N., J.P. Bay Road, New Town.  
 1921 Oldham, W. C. 39 George Street, Launceston.  
 1924 Oliver, H. Lindisfarne.  
 1927 Orme, K. "Sydney Lodge," Brisbane Street, Hobart.  
 1921 Overell, Miss Lilian. Holebrook Place, Hobart.  
 1921 Padman, R. S. 56 St. John Street, Launceston.  
 1923 Parker, Dr. G. M. Bellerive.  
 1923 Parker, H. T., M.A. "Montana," Bellerive.  
 1921 Patten, W. H. 59 Cameron Street, Launceston.  
 1929 Pearce, Harold. Ellington Road, Lower Sandy Bay.  
 1923 Pedder, A. Stoke Street, New Town.  
 1927 Penman, C. J. Smelting Works, Launceston.  
 1902 Piesse, E. L., B.Sc., LL.B. "Merridale," Sackville  
 Street, Kew, Melbourne.  
 1910 Pillinger, J. 4 Fitzroy Crescent, Hobart.  
 1926 Pitman, Professor E. J. G., B.A., B.Sc. The Univer-  
 sity, Hobart.  
 1925 Pratt, A. W. Courtney. "Athon," Mount Stuart Road,  
 Hobart.  
 1925 Propsting, G. L. Earl Street, Sandy Bay.  
 1923 Purcell, G. A. Clemes College, Hobart.  
 1927 Raymond-Barker, A. B. Darcy Street, Hobart.  
 1929 Read, W. D. The University, Hobart.  
 1921 Reid, A. McIntosh. Director of Mines, Hobart.  
 1922 Reid, A. R. Curator, Beaumaris Zoo, Domain, Hobart.  
 1925 Reid, Miss M. L. The University, Hobart.  
 1921 Reid, W. D. Public Buildings, Launceston.  
 1929 Rex, R. R. The Wharf, Hobart.  
 1921 Reynolds, John. 25 Tower Road, New Town.  
 1928 Richardson, F. B., M.A. 60 Augusta Road, New Town.  
 1925 Robinson, F. G. 42 Regent Street, Sandy Bay.  
 1926 Robson, Mrs. "Elsmore," Richards Avenue, Elphin  
 Road, Launceston.  
 1929 Roche, M. M. Mines Department, Hobart.  
 1884 Rodway, L., C.M.G. 77 Federal Street, Hobart.  
 1921 Rolph, W. R. *Examiner* and *Courier* Office, Launces-  
 ton.  
 1913 Ross, Hector. Cambridge, Tasmania.  
 1922 Sargison, H. Elizabeth-street, Hobart.  
 1921 Savigny, J. A.M.P. Chambers, Launceston.

Year of  
Election.

- 1896 Scott, H. H. Curator, Queen Victoria Museum, Launceston.
- 1928 Scott, R. A. Department of Agriculture, Hobart.
- 1896 Scott, R. G., M.B., Ch.M. 104 High Street, Sandy Bay, Hobart.
- 1927 Shield, R. J. 122 Collins Street, Hobart.
- 1921 Shields, Honourable Tasman, M.L.C. 13 Paterson Street, Launceston.
- 1925 Shoobridge, K. Macquarie Plains, Tasmania.
- 1921 Shoobridge, Honourable L. M., M.L.C. "Sunnyside," New Town.
- 1925 Shoobridge, Rupert. "Fenton Forest," Glenora.
- 1923 Shoobridge, S. E. C/o Messrs. H. Jones and Co., Hobart.
- 1927 Shugg, Dr. Macquarie Street, Hobart.
- 1923 Simson, Mrs. L. 3 St. George's Square, Launceston.
- 1927 Smith, Miss Marjorie. C/o *The Countryman*, 4 St. James's Buildings, 123 William Street, Melbourne, C.I.
- 1925 Smith, Colonel R. P. A.M.P. Society, Hobart.
- 1921 Smithies, F. 34 Paterson Street, Launceston.
- 1925 Stackhouse, C. K. R. 55 Paterson Street, Launceston.
- 1928 Steele, R. B., B.Sc. Department of Agriculture, Hobart.
- 1929 Stephens, C. S. The University, Hobart.
- 1927 Sweetnam, H. W., M.B., Ch.B. Macquarie Street, Hobart.
1920. Swindells, A. W. C/o Messrs. Murdoch Bros., Market Place, Hobart.
- 1927 Tankard, L. W. Sheffield, Tasmania.
- 1918 Taylor, W. E. Elboden Street, Hobart.
- 1929 Thirkell, Major R. W., O.B.E., V.D. 405 Elizabeth Street, Hobart.
- 1929 Thomas, A. J. H. 52 Letitia Street, Hobart.
- 1923 Thomas, J. F. Room 8, Wilga Chambers, 158 Phillip Street, Sydney.
- 1922 Thomas, Lieutenant-Colonel L. R., D.S.O. Registrar of the Tasmanian University, Hobart.
- 1921 Thomas, P. H. Agricultural Department, Hobart.
- 1922 Thompson, E. H. Lower Sandy Bay.
- 1928 Tribolet, D. R. 34 Proctor's Road, Hobart.
- 1926 Turner, A. Jefferis, M.D., F.E.S. Wickham Terrace, Brisbane, Queensland.
- 1927 Turner, J. W. Mona Street, Battery Point.

Year of  
Election.

- 1923 Urrwin, E. E., M.Sc. Commercial Road, New Town.  
1927 Walch, J. H. B., M.B. 71 Crescent Road, West Hobart.  
1918 Walch, P. B. C. King Street, Sandy Bay.  
1928 Walters, Rev. Walter. Scottsdale, Tasmania.  
1926 Ward, F. E. Director of Agriculture, Hobart.  
1913 Wardman, John. Superintendent Botanical Gardens,  
Hobart.  
1918 Waterhouse, G. W. Messrs. Ritchie and Parker,  
Alfred Green and Co., Launceston.  
1922 Watson, D. W. "Undine," Glenorchy.  
1926 Waugh, Eric C., LL.B. High Street, Sandy Bay.  
1922 Wayn, Miss A. L. C/o Chief Secretary's Department,  
Hobart.  
1927 Wells, Frank. 16 Montagu Avenue, New Town.  
1927 Whishaw, R., M.B., Ch.M. Macquarie Street, Hobart.  
1929 White, C. G. The University, Hobart.  
1926 Whittle, B. H. Augusta Road, New Town.  
1925 Winch, M. C/o Brownells Ltd., Hobart.  
1901 Wise, H. J. Lambert Avenue, Sandy Bay.



## ANNUAL REPORT

1929.

### *The Council and Officers.*

The Annual Meeting was held at the Society's Rooms, The Tasmanian Museum, Hobart, on 11th March, 1929.

The following were elected as members of the Council for 1929:—Dr. A. H. Clarke, Dr. W. E. L. Crowther, Messrs. J. A. Johnson, A. V. Giblin, A. N. Lewis, E. E. Unwin, L. Rodway, F. E. Ward, and Clive Lord (*ex officio*).

During the year nine meetings of the Council were held, the attendance being as follows:—Dr. Clarke 8, Dr. Crowther 8, Mr. Clemes 8, Mr. Lord 9, Mr. Giblin 7, Mr. Rodway 6, Mr. Lewis 6, Mr. Johnson 6, Mr. Unwin (6 months' leave of absence whilst in England) 2, Mr. Ward 5.

The Council at its first meeting made the following appointments:—

Chairman of the Council: Dr. A. H. Clarke,  
M.R.C.S., L.R.C.P.

Secretary: Mr. Clive Lord.

Hon. Treasurer: Dr. W. E. L. Crowther.

Standing Committee: Messrs. Clemes, Lewis, and Lord.

Editor of the Papers and Proceedings: Mr. Clive Lord.

Trustees of the Tasmanian Museum and Botanical Gardens: Dr. Clarke, Dr. Crowther, Messrs. Lewis, Giblin, Clemes, and Ward.

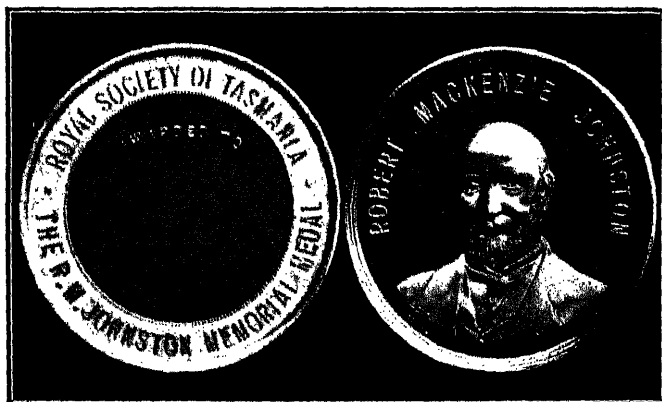
### *Meetings.*

During the year nine ordinary and two special meetings were held, and the attendance of members at the meetings was well maintained. Details of the meetings are recorded in the Abstract of Proceedings.

### *R. M. Johnston Memorial.*

The Council elected Dr. R. J. Tillyard, F.R.S., as the R. M. Johnston Medallist for 1929. Dr. Tillyard delivered the

R. M. JOHNSTON MEMORIAL.

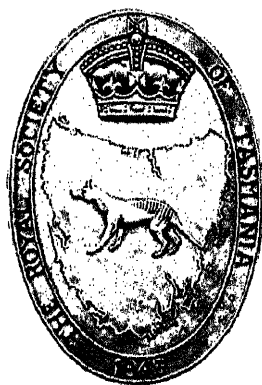


THE R. M. JOHNSTON MEMORIAL MEDAL.

List of Awards:

- 1923 Sir T. Edgeworth David, K.B.E., C.M.G., B.A., F.R.S., F.G.S.
- 1925 Professor F. Wood-Jones, M.B., B.S., M.R.C.S., L.R.C.P., D.Sc.
- 1929 R. J. Tillyard, M.A., Sc.D. (Cantab.), D.Sc., F.R.S., F.N.Z. Inst.,  
F.L.S., &c.





THE ROYAL SOCIETY OF TASMANIA MEDAL.

List of Awards:

1927 I. Rodway, C.M.G.

Note.—The Royal Society of Tasmania Medal was established in 1927. It is awarded for eminence in research and for work of outstanding merit on behalf of the Society and the State (*vide* Abstract of Proceedings, P. & P., 1927, pp. 212-214).



lecture on 14th October, his title being:—"The Biological Control of Noxious Weeds," and afforded another example of the value of the R. M. Johnston Memorial Lectures.

*General.*

The work of the Society has been well maintained, and reference to the Branch and Sectional Reports shows that activity has been present in other matters apart from the general routine work. Particular attention might be directed to the valuable work done by the botanical section during the past year.

*Library.*

Considerable additions have been made to the Library during the year, but the housing and cataloguing of the Library is still a matter of grave concern. The Government assistance given towards cataloguing, &c., has been of some help, but until additional space is provided it is impossible to provide properly for the care of the ever-growing and valuable collection of reference works which the Society is privileged to possess.

*Obituary.*

It is with regret that the Society has to report the deaths of the following members:—Messrs. David Barclay, F. Weber, and W. H. Bennett.

## NORTHERN BRANCH

### ANNUAL REPORT FOR 1929.

The following were elected Northern Council for 1929:—Hon. T. Shields, Messrs. Heritage, Miller, Rolph, Smithies, Forward, Heyward, Reid, and Dr. Nelson; Secretary and Treasurer, R. S. Padman.

The scientific films loaned by the Kodak Co., through the services of Mr. Spurling, attracted a large number of the public, in addition to our own members.

In August Mr. Clive Lord gave an interesting illustrated lecture on "Flinders as an Explorer." Mr. Jebb acted as lanternist.

We were disappointed on several occasions this year by lecturers who had promised us papers unexpectedly leaving Launceston before arrangements could be finalised.

## SECTION REPORTS

### BOTANICAL SECTION.

The Section has directed its main activities towards the progress of the Tasmanian Museum Herbarium, and the co-operation of the Section with the Museum authorities has resulted in a very decided advance being made.

Under the direction of Mr. Leonard Rodway, C.M.G., considerable progress has resulted. Specimens representing over 700 species have been added to the Herbarium, leaving some 500 species still needed to complete the collection of higher plants. Approximately 3,000 specimens have been mounted and identified, and two consignments have been despatched to the Royal Botanic Gardens, Kew, and to Canberra towards duplication of our Herbarium at each of these places.

The Director attends at the Herbarium at least two mornings in each week, and his services are frequently availed of by the officers of the Agricultural Department to identify herbage, grasses, poisonous shrubs, and weeds.

A collection of live plants, presented by Dr. A. W. Hill, of the Royal Botanic Gardens, Kew, which comprises 40 species new to Tasmania, arrived in excellent condition, and is now being acclimatised at the Botanical Gardens under Mr. J. Wardman's capable supervision.

The Vernacular Index is in hand, and a fair amount of matter collected for this purpose.

The Museum authorities have made the services of Miss J. Gould available for herbarium work several days a week, and this will prove of assistance to the Section.

The visit of Mr. H. F. Comber to Tasmania for collecting purposes has stimulated the work of the section, and his wide botanical knowledge has been of great assistance, freely given, and cordially appreciated.

Mrs. Leonard Rodway's work in the Herbarium deserves special mention, as she attends regularly with the Director, and has done a vast amount of work.

A parcel of Tundra grass seeds is in transit from the Marussino Experiment Station of Meadow Culture, Mor-

shansk, Tambov Government, Russia, for experimental purposes to find whether they will improve the sheep pasture of our lake country.

A. V. GIBLIN,

Hon. Secretary.

#### EDUCATION SECTION.

Members: Mr. J. A. Johnson (Chairman), Messrs. E. E. Unwin, L. Dechaineux, H. T. Parker, W. H. Clemes, T. W. Blaikie, L. F. Giblin, Reynolds, Newall, H. Eyre, C. W. McFarlane, D. H. Tribolet (Hon. Sec.).

Average Attendance: Seven members.

#### *Papers.*

"History of the Education Section." Mr. J. A. Johnson, M.A.

"Character and the Curriculum." Mr. H. T. Parker, M.A.

"Art and Citizenship." Mr. L. Dechaineux.

"Civic Responsibilities of Education." Mr. Reynolds.

"Adult Education." Mr. Newall.

"Education Among the Vikings." Professor Giblin.

"Artisan Education for Citizenship." Mr. H. Eyre.

"Education in England." Mr. E. E. Unwin. M.Sc.



# THE ROYAL SOCIETY OF TASMANIA.

## GENERAL FUND.

### STATEMENT OF RECEIPTS AND EXPENDITURE, 1929.

RECEIPTS.			EXPENDITURE.		
	£	s. d.		£	s. d.
Balance brought forward . . .		0 17 7	Salaries . . . . .		39 10 0
Subscriptions—			Papers and Proceedings—		
Arrears . . . . .	12	12 0	1928 (Part) . . . . .	184	13 0
Current . . . . .	243	3 0	1929 (Part) . . . . .	30	16 8
Sale of Publications . . . . .		246 15 0	Printing, General . . . . .		215 9 8
Government Grant . . . . .		9 7 6	Library . . . . .		28 17 9
Rent of Room . . . . .		100 0 0	Insurance . . . . .		32 17 6
Miscellaneous . . . . .		11 15 0	Light and Fuel . . . . .		5 18 9
Advance from M.A.M. Fund . .		0 14 4	Petty Cash and Postages . . .		5 15 4
		1 0 0	Northern Branch . . . . .		9 15 3
			Miscellaneous . . . . .		13 5 4
					18 10 3
			Balance carried forward . . . . .	£369	19 10
					0 9 7
				£370	9 5

Examined and certified to be correct,

WALTER E. TAYLOR, F.F.I.A.,  
Hon. Auditor.

14th January, 1930.

CLAVE E. LORD, Secretary.

WILLIAM L. CROWTHER, Hon. Treasurer.

11th January, 1930.

**THE ROYAL SOCIETY OF TASMANIA.**  
**MORTON ALLPORT MEMORIAL FUND, 1929.**

RECEIPTS.		EXPENDITURE.	
	£ s. d.		£ s. d.
Balance brought forward . . . . .	2 9 6	Purchase of Books for Society's Library ..	7 3 0
Interest . . . . .	10 4 0	Loan to General Fund . . . . .	1 0 0
		Balance carried forward . . . . .	£8 3 0
	<u>£12 13 6</u>		4 10 6
			<u>£12 13 6</u>

Examined and certified to be correct,

WALTER E. TAYLOR, F.F.I.A.,  
Hon. Auditor.

14th January, 1930.

CLIVE E. LORD, Secretary.

WILLIAM L. CROWTHER, Hon. Treasurer.

11/1/30.

£200 was raised by Public Subscription in 1878 to establish a Memorial to the late Morton Allport. The Fund is invested in the name of the Perpetual Trustees, Executors, and Agency Co. of Tasmania Ltd., and the income is used for the purchase of Books for the Library of the Society.

**R. M. JOHNSTON MEMORIAL FUND.  
RECEIPTS AND EXPENDITURE FOR 1929.**

RECEIPTS.		EXPENDITURE.	
	£ s. d.		£ s. d.
Balance brought forward . . . . .	11 0 0	Supplement to Mathew's "Birds of Australia," . . . . .	10 10 0
Interest . . . . .	14 12 0	Books for Library . . . . .	12 3 6
		Balance carried forward . . . . .	£22 13 6
			2 18 6
			£25 12 0

Examined and certified to be correct,

WALTER E. TAYLOR, F.F.I.A.,  
Hon. Auditor.

14th January, 1930.

CLIVE E. LORD, Secretary.  
WILLIAM L. CROWTHER, Hon. Treasurer.

11th January, 1930.

The Memorial to the late R. M. Johnston was established in 1921. The income from the Fund raised by Public Subscription is used for the purchase of Books for the Library, and for the Memorial Medal awarded to the late R. M. Johnston lecturer from time to time.

THE ROYAL SOCIETY OF TASMANIA.

NORTHERN BRANCH.

ANNUAL FINANCIAL STATEMENT FOR YEAR ENDING DECEMBER, 1929.

	£	s.	d.		£	s.	d.
Balance brought forward . . . . .	33	4	10	Printing . . . . .	1	18	0
Interest . . . . .	1	6	5	Advertising . . . . .	1	2	0
Share of Subscriptions . . . . .	13	5	4	Freight and Expenses Kodascope . . . . .	1	2	6
				Expenses to Lecturer . . . . .	2	2	6
				Postages and Petty . . . . .	0	15	0
				Balance in Bank . . . . .	40	16	7
					£47	16	7

R. STEWART PADMAN,

Hon. Sec. and Treasurer.

J. E. HERITAGE,

Hon. Auditor.

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THE ROYAL SOCIETY  
OF  
TASMANIA

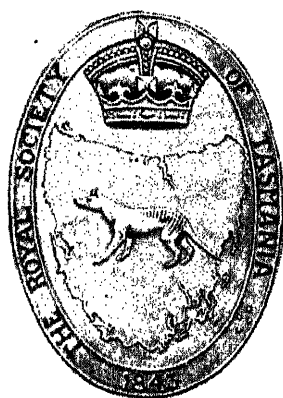




PAPERS & PROCEEDINGS  
OF  
THE ROYAL SOCIETY  
OF TASMANIA

FOR THE YEAR

1930



(With 7 Plates and 29 Text Figures)

ISSUED 17th MARCH, 1931

PUBLISHED BY THE SOCIETY

The Tasmanian Museum, Argyle Street, Hobart

1931

*Price : Ten Shillings*

The responsibility of the statements and opinions in the following papers and discussions rests with the individual authors and speakers; the Society merely places them on record.

# THE ROYAL SOCIETY OF TASMANIA

---

The Royal Society of Tasmania was founded on the 14th October, 1843, by His Excellency Sir John Eardley Eardley, Willmot, Lieutenant Governor of Van Diemen's Land, as "The Botanical and Horticultural Society of Van Diemen's Land." The Botanical Gardens in the Queen's Domain, near Hobart, were shortly afterwards placed under its management, and a grant of £400 a year towards their maintenance was made by the Government. In 1844, His Excellency announced to the Society that Her Majesty the Queen had signified her consent to become its patron; and that its designation should thenceforward be "The Royal Society of Van Diemen's Land for Horticulture, Botany, and the Advancement of Science."

In 1848 the Society established the Tasmanian Museum; and in 1849 it commenced the publication of its "Papers and Proceedings."

In 1854 the Legislative Council of Tasmania by "The Royal Society Act" made provision for vesting the property of the Society in trustees, and for other matters connected with the management of its affairs.

In 1855 the name of the Colony was changed to Tasmania, and the Society then became "The Royal Society of Tasmania for Horticulture, Botany, and the Advancement of Science."

In 1860 a piece of ground at the corner of Argyle and Macquarie streets, Hobart, was given by the Crown to the Society as a site for a Museum, and a grant of £3,000 was made for the erection of a building. The Society contributed £1,800 towards the cost, and the new Museum was finished in 1862.

In 1885 the Society gave back to the Crown the Botanical Gardens and the Museum, which, with the collections of the Museum, were vested in a body of trustees, of whom six are chosen from the Society. In consideration of the services it had rendered in the promotion of science, and in the formation and management of the Museum and Gardens, the right was reserved to the Society to have exclusive possession of sufficient and convenient rooms in the Museum, for the safe custody of its Library, and for its meetings, and for all other purposes connected with it.

In 1911 the Parliament of Tasmania, by "The Royal Society Act, 1911," created the Society a body corporate by the name of "The Royal Society of Tasmania," with perpetual succession.

The object of the Society is declared by its Rules to be "the advancement of knowledge."

His Majesty the King is Patron of the Society; and His Excellency the Governor of Tasmania is President.

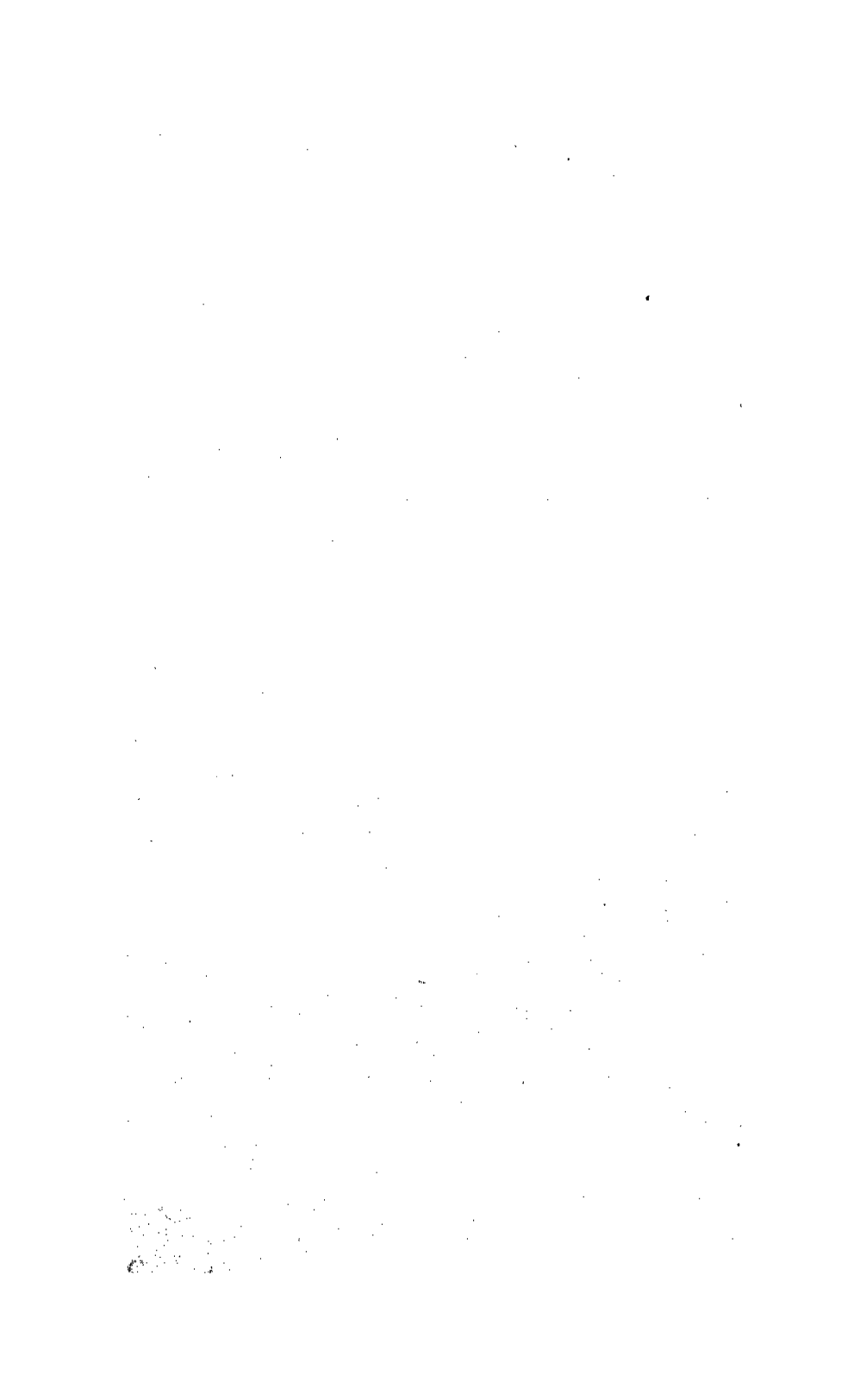


# THE ROYAL SOCIETY OF TASMANIA

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# PAPERS

## OF

# THE ROYAL SOCIETY OF TASMANIA

## 1930

### THE EVOLUTION OF THE CLASS INSECTA.\*

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With 19 Text Figures.

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## INTRODUCTION.

The subject of this paper is one which is admittedly full of difficulty, yet at the same time one of the profoundest interest, viz., the Evolution of the Insects as a Class from some ancestral type which was not an Insect, but something more primitive in its general structure. In attempting this task, I must first of all classify and pass in review the various theories that have been advanced by famous zoologists or entomologists to account for the origin of this Class, admittedly the highest development within the Phylum Arthropoda. Each main hypothesis will be examined on its merits and tested as to its validity. Having carried out this task, I then propose to state the position as it appears to me and to offer a new theory which attempts to embrace all the known facts of the case.

## SECTION I.

## EXISTING THEORIES.

One method of examining the theories already put forward about the origin of the Class Insecta would be to keep to strict chronological order and deal with each separate theory as it was presented by its author. This would be a long and, I fear, somewhat tedious process. Moreover, these theories are of very unequal merit, and some of them most certainly do not deserve special treatment, as they have not been worked out with the care and thoroughness which we have a right to demand from any author who would try to bring the scientific world to accept his views. Also, it so happens that a particular theory, after enjoying a period of popularity for a span of years, sinks into oblivion against the greater brilliance of some newer theory. Then, after a further period, another author comes along, refurbishes up the old theory and adds a few more tempting tit-bits to it, and back we swing to the older outlook with a fresh polish on it. Thus, if I attempted the historical method, I should be keeping your minds swinging back and forth between one type of theory and another, and you would merely be studying the trees instead of trying to get a general view of the whole wood.

So I shall attempt in this instance another method, viz., to classify the known theories of the origin of Insects into definite groups. This will enable you to follow the

evolution of the theories themselves, even if it does not help you much to follow the evolution of the Insects.

Now, in order to classify and study these theories, let us first of all examine the question of what types of animals may be brought into the question.

Obviously, we may reject from the start all those theories which attempt to derive the Insecta from something very far back and extremely simplified by comparison with them. It does not, for instance, take a very acute mind to put forward the theory that Insects are derived from Annelid Worms! If anyone has done so, no doubt you will all with one accord make the obvious rejoinder "That is too easy a solution; for it seems highly probable that the whole of the Phylum Arthropoda is so derived." Nevertheless, I would not altogether reject such a theory. I would only insist that, for it to be taken into account, it must present a fairly complete picture of the lines of evolution of the various groups of Arthropoda from the Annelids, and, in the special case of the Insecta, fill in the wide gap between the creeping worm and the highly specialised flying insect. It is for this one reason that I feel compelled to pass over Walton's theory (1927) of the origin of Insects direct from Polychæta with a few remarks and a reference at the end of this address, to enable those of you who so desire to study the theory for yourselves. Walton simply sets forth the general idea that both the leg and the wing of the insect have been derived from the parapodium of a Polychæt worm, the leg being a specialised development from the neuropodium and the wing from the notopodium. He makes no attempt to explain how it is that, in this case, all the segments of the insect's body do not possess wings and legs; he merely indicates that the wings, being dorso-lateral, could best have come from the notopodium, while the legs, being ventro-lateral, could best have come from the neuropodium. No attempt is made to show the evolution of the intermediate stages between these two extremes, nor to indicate the known fossil types that should surely stand somewhere near the line of evolution; nor is any attempt made to show how the complex musculature of the insect leg or wing could be derived from the extremely simple and, histologically, very different, musculature of the worm. Walton's theory, then, in spite of a certain amount of intriguing suggestiveness, must be put outside the main feast of rea-

son, and must be partaken of, if swallowed at all, as a simple *hors d'œuvre!*

This brings me to my first main proposition, viz., that any theory of the evolution of Insects, to be acceptable, must either show their origin from a lower type of Arthropod, or, if not that, must at least indicate the relationships that exist between Insects and those groups of Arthropods nearest to them. You will note that I ask specifically, not for a derivation from any *living* type of Arthropod, though some authors are so obliging as to offer this type of solution, but at any rate either from some ancient fossil type of Arthropod, or, if not that, then from some carefully reasoned hypothetical common ancestor shared by Insects and some related group or groups. Let us begin with a careful consideration of existing theories concerning the origin of Insects. I shall take first of all those which seek to derive the Insecta from Marine Arthropoda. These can be divided into two groups, as follows:—

- I. Descent of the Insecta from Trilobita. *Handlirsch's Theory.*
- II. Descent of the Insecta from Crustacea. Various theories culminating in *Crampton's Theory.*

#### I. HANDLIRSCH'S THEORY.

Handlirsch's Theory of the evolution of Insects from Trilobites was first published in full form in 1908 and was again very ably summarised by the author in 1913. It forms almost a perfect model in completeness of presentation and carefulness of argument, and therefore must merit our fullest attention. The author was a student of the great Austrian entomologist, Brauer, and was therefore originally predisposed towards Brauer's well-known Campodea-Theory. During the course of a long life, he has gained as wide an experience of insects in general as any living man, and he is well known as the author of a monumental work on Fossil Insects (1908), in which his theory is very fully set forth. I propose here to give you a succinct account of the theory itself, and then to offer some criticisms of it.

According to Handlirsch, the winged insects or Pterygota (which he calls Pterygogenea) are the original Insecta, and the ancestral type is to be found in the Order Palæodictyoptera of the Upper Carboniferous. This type carried the fore and hind wings outspread as in the Anisopterous

Dragonflies, but it also possessed rudimentary wings on the prothorax, and the abdominal segments were provided with small side-processes of the tergites, known as paranota.

Handlirsch then sets out to prove that the wings of the Pterygota are simply specialisations from the original paranotal or pleural expansions of the tergites found in the Trilobites. This, of course, is not difficult. There are only two possible theories of the origin of insect wings; one theory holds that they were originally gills, and that, therefore, the ancestral winged insect must have been aquatic; the other theory holds that they are lateral expansions of the thoracic nota. The majority of entomologists now support the latter theory; so Handlirsch appears to be on very sound ground here.

Handlirsch then addresses himself to the question as to whether any Trilobite ever existed that could possibly have been the direct ancestor of the Pterygota. His argument on this point runs thus:—We know of Trilobites with few postcephalic segments, as well as Trilobites with many such segments; somewhere between the two extremes there must have been forms in which the segmentation of the body was exactly that required to give rise to the segmentation found in Pterygota. (This we may readily admit, without thereby accepting it as proof that such a form, if it existed, was the actual ancestor of the Insects.) Again, he says, we know of Trilobites with narrow bodies as well as Trilobites with broad bodies; also we know of Trilobites possessing a pair of compound eyes and three ocelli, exactly as in Insects, and at least one genus of Trilobites is also known which possessed a pair of terminal, many-jointed cerci. Further, all Trilobites agree with Insects in possessing only one pair of simple antennæ.

All the above points are well made, as far as they go, and we can admit them as indicating quite clearly *what kind* of Trilobite *might have been* the ancestor of the Pterygota. But none of them prove that any such Trilobite *was* actually the ancestor we are looking for, and I am sure you will all note with me that most of the characters enumerated by Handlirsch are so primitive that there is still quite a long gap to fill between Handlirsch's ancestral Trilobite form and a Palæodictyopterous Insect. This gap Handlirsch very cleverly fills by giving a reconstruction of his idea of what the larva or nymph of a Palæodictyopteron must have been like (figs. 1, 2, 3). When you look at these

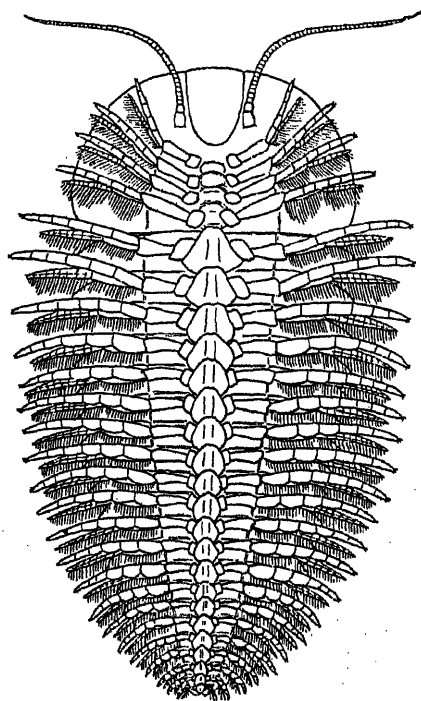


Fig. 1. A Trilobite, *Triarthrus becki*, Green. Ventral view, restoration.  
After Beecher.

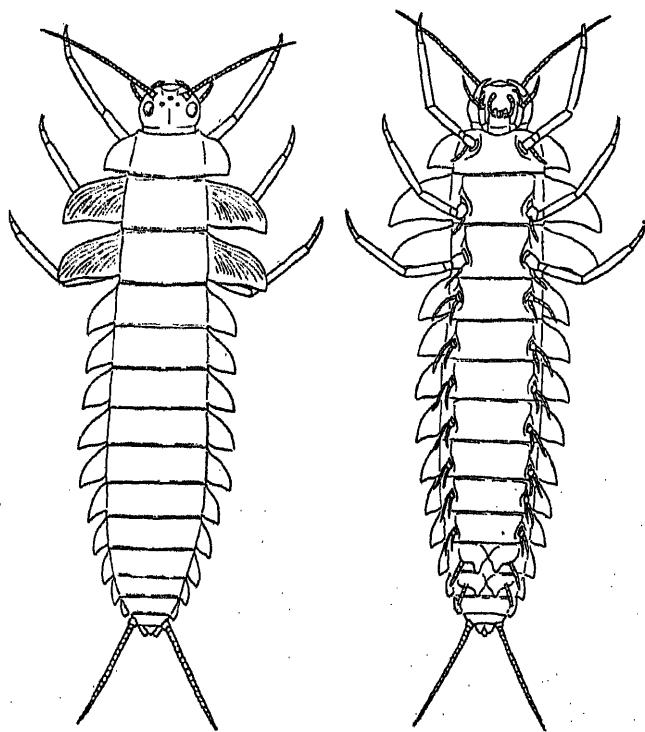


Fig. 2. Reconstruction of the larva of the original ancestor of the Insecta, according to Handlirsch. (Order Paleodictyoptera, Upper Carboniferous.)

Left, dorsal, and right, ventral view. After Handlirsch.

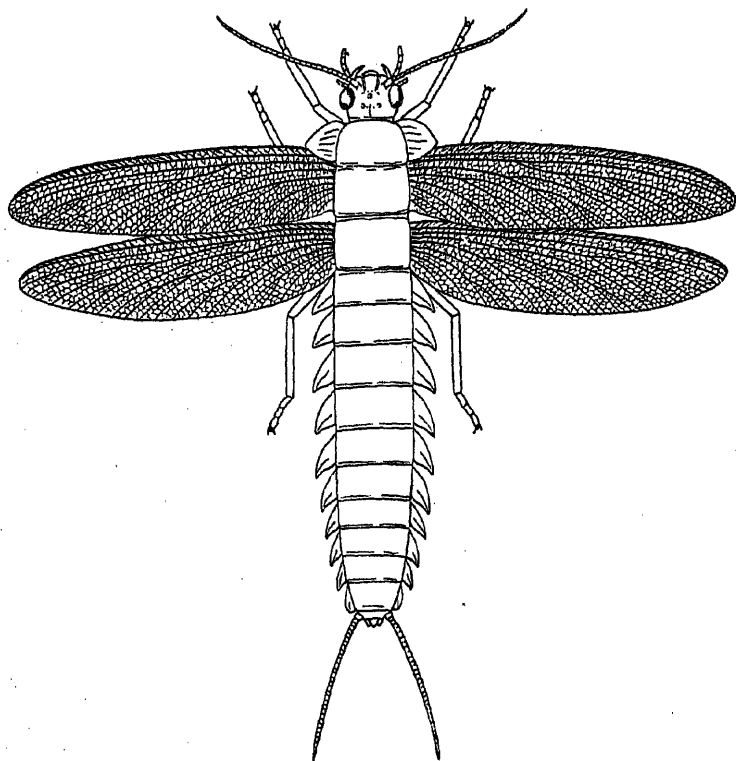


Fig. 3. Reconstruction of the imago of the original ancestor of the Insecta, according to Handlirsch. (Order Palæodictyoptera, Upper Carboniferous.)

Dorsal view. After Handlirsch.

three figures side by side, the Trilobite, the larval Palæodictyopteron and the adult Palæodictyopteron, you feel that Handlirsch has presented a good case.

Further, Handlirsch also drives home his argument palæontologically. The Trilobites lived from the Lower Cambrian to the Permian; thus there was an immense period of geologic time during which some shallow-water form of Trilobite could have worked its way up the estuaries into brackish water, thence into fresh water, and finally could have developed into the flying insect. Handlirsch, be it noted, places the origin of the Insecta as not lower than the Lower Carboniferous or, at the earliest, in the Upper Devonian (see fig. 4).

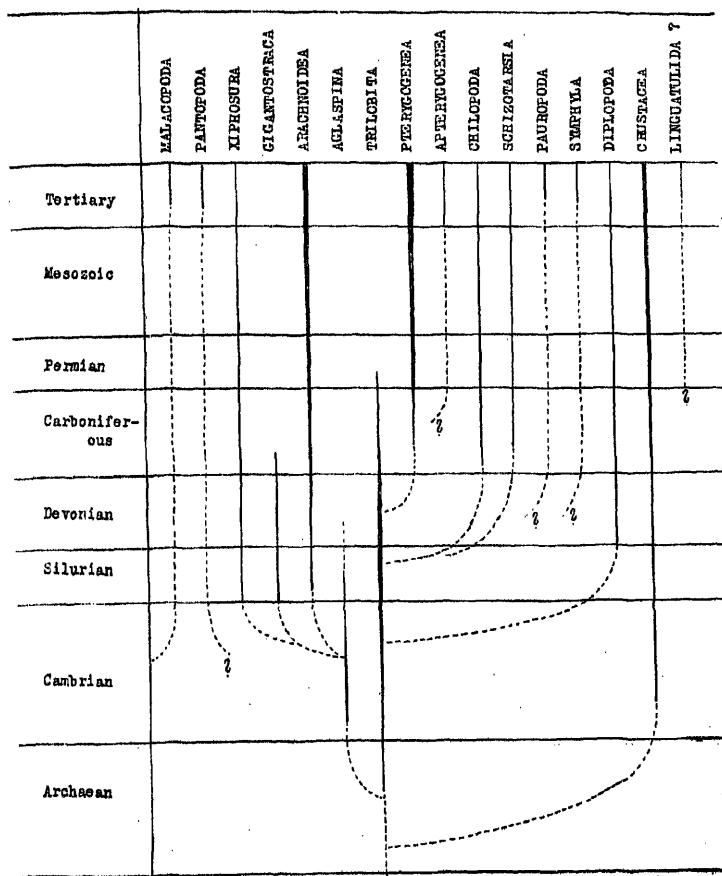


FIG. 4. Phylogeny of the Arthropoda, according to Handlirsch (1913).

Handlirsch's Theory, though primarily devised to explain the origin of Insects, actually covers the whole of the Arthropoda. He casts out the Onychophora as not being true Arthropods, and then boldly claims that all the other Classes of Arthropods, exclusive of the Tardigrades and Pentastomida, are derived from Trilobites.

Before attempting to offer criticisms of this theory in general, let us see how Handlirsch deals with the most obvious criticism of all. It is very hard for any entomologist to believe that the original ancestral type of the Insecta was a winged insect. But, if the ancestral form was not a



winged but a primitively wingless insect, then Handlirsch's theory has its very foundation knocked from under it; for it is founded primarily on the evolution of the insect wing direct from the pleuron of the Trilobite. Hence Handlirsch is put into the position of having to defend the thesis that the known Apterygota are degenerate descendants of originally winged insects. This he does in characteristic fashion. He asks the question:—To which of the groups of Apterygota are the Pterygota most obviously allied? The answer, with which we must all agree, is that they are most closely related to the Ectotrophous Thysanura, viz., the Machilidæ and the Lepismatidæ. He then puts aside the Machilidæ, evidently because they were laterally flattened, jumping forms, and centres his argument on the Lepismatidæ, which are dorso-ventrally flattened, running forms which possess definite paranota on the thorax. Then, dealing with the paranotal flaps of *Lepisma*, he quotes (1913) an unpublished observation given to him by Dr. Sulc, who states that the tracheation of the lateral flap of the thoracic notum in this insect can be homologised with the typical tracheation of the larval wing in the Pterygota. Even accepting this observation, he has to confess that the matter is "not proven," though, for his part, he holds that these flaps are not the rudiments but the vestiges of original wings.

Now Handlirsch lays himself open to a serious attack here, and we must drive it home. Careful dissections of the thoracic flaps of *Lepisma* made by Mr. Tonnoir in Canberra show quite clearly that Dr. Sulc's observation is incorrect. The tracheation of these flaps is not of a fixed type; it varies in important details both in individuals, in the different segments of the thorax, and also on right and left sides. Only a person who was determined to find, at all costs, a series of homologues to the six main tracheæ of the insect wing could possibly do so, and even then he would have to choose the most suitable of the many variations and more than stretch a point in homologising the tracheal branches. Thus we must insist that there is really no evidence in favour of Handlirsch's view, and, as we shall see when we come to review the whole problem, there is also an immense mass of evidence against it.

Again, we have another criticism to level against the theory on palæontological grounds. If Handlirsch is right, the Pterygota must be older than any of the Apterygota. This did not give him much trouble, because, at the time

that he wrote, the only known fossil Apterygota were Tertiary. So he puts the Pterygota as originating in the Lower Carboniferous, or at the very earliest in the Upper Devonian, and then indicates an origin for the various groups of Apterygota, somewhere in the Carboniferous. But, unfortunately for the theory, I have since been able to prove (1928) that true Collembola, closely resembling living Poduridæ, were present in the peat-bogs of the Lower Devonian, along with Acarids, Crustacea, and the most primitive types of vascular plants. Hence, if Handlirsch's theory is correct, Pterygota must have existed even before that time! This is a thing that nobody could believe; not only because no fossil winged insects are known before the Upper Carboniferous, but also because there were no trees in existence at that time, and little food suitable for anything but a crawling, creeping, or swimming form. I feel myself that this discovery of Lower Devonian Collembola has given Handlirsch's theory a very severe blow indeed.

On minor morphological points, Handlirsch is also open to criticism. He makes no attempt to indicate how the insect mandible has been evolved from the primitive biramous limb of the Trilobite head. No known insect has a mandible with either endopodite, exopodite, or epipodite still present. Surely we are entitled to be given some guide as to the intermediate stages. Further, and this is a grave mistake, in all his figures of Trilobites, Handlirsch entirely ignores the separation of the pygidium from the thoracic region; and I can only conclude that he either overlooked this point, which is a serious one, or desired to carry his ancestral form so far back that its pygidial segments were to be conceived of as being in a primitively unfused condition. For it is obvious, I think, that no form of Trilobite which already had two or more primary body-segments fused together to form a pygidium could possibly be the ancestor of the Insects.

To conclude, then, Handlirsch's theory, fascinating as it is, is not acceptable on many grounds, and we must look elsewhere for our solution.

## II. THE DESCENT OF INSECTS FROM CRUSTACEA.

The idea that Insects are descended from Crustacea can be traced back a very long way. The essential difference between Handlirsch's Theory and all the variations of belief in the descent of Insects from true Crustacea lies in this:—

In the former, the ancestral group is extremely primitive, and the gap to be filled between it and the Insecta is very wide; in the latter, the descent is claimed to be from an already highly organised Crustacean type, by a transference from marine to terrestrial conditions, to a primitive type of wingless Insect. As we shall see in the course of our study, the particular type to which all these theories direct attention is the family Machilidæ, which all are unanimously agreed upon is the most Crustacea-like of Insects.

The first clear enunciation of the theory of descent from Crustacea was that by Hansen (1893), who received support from Ray Lankester (1904), G. H. Carpenter (1903, 1905), and Börner (1909). The basis of Hansen's theory may be stated in his own words (1893, pp. 427, 428) :—

"I regard the maxillæ in *Machilis* as decidedly homologous with the maxillæ (second pair of maxillæ of authors) in the Malacostraca, and the labium as homologous with the maxillipedes and agreeing in many respects with these appendages in the case of the groups mentioned." (The groups referred to are the Isopods and, more especially, the Amphipods.)

"The hypopharynx" (i.e., in *Machilis*) "is conspicuous . . . and homologous with the hypopharynx (paragnathi) in the Malacostraca. The organs which are termed 'paraglossæ' by authors have nothing to do with the hypopharynx. . . . I regard these 'paraglossæ' as homologous with the maxillulæ of Crustaceans."

Hansen's theory was more fully developed by Carpenter (1903, 1905). We might here note that Hansen used the term "endopodite" to include both the basal segments ("protopodite" of authors) and inner ramus ("endopodite" of authors) but we shall follow the usual terminology and restrict the term to the inner ramus.

The complete theory of Hansen and Carpenter may be considered to comprise the following points:—

- (a) The compound eyes of Insects are morphologically the same as the compound eyes of Crustacea and belong to the same head-segment.
- (b) The antennæ of Insects are homologous with the antennules or first antennæ of Crustacea.

- (c) The second antennæ, or antennæ, of Crustacea are entirely suppressed in the Insecta, the segment which originally bore them being the intercalary or third head-segment.
- (d) The mandibles of Insects are homologous with those of Crustacea, and have been directly derived from them by loss of the endopodite.
- (e) The superlinguæ or maxillulæ of Insects are homologous with the first maxillæ, or maxillulæ, of Crustacea.
- (f) The hypopharynx of Insects is homologous with the paragnaths of Crustacea, and has nothing to do with the maxillulæ or paraglossæ.
- (g) The first maxillæ of Insects are homologous with the second maxillæ, or maxillæ, of Crustacea.
- (h) The typical head of a Crustacean is therefore composed of six fused segments, three pre-oral and three post-oral, to which the first thoracic segment becomes sometimes closely applied, its appendages then becoming the first maxillipedes.
- (i) The typical head of an Insect is composed of seven fused segments, three pre-oral and four post-oral, the seventh representing the first thoracic of Crustacea, and its appendages being fused together to form the labium or second maxillæ.

It might be noted that the Machilidæ are held to be the most primitive of all Insects, on this theory, on account of their general close resemblance to Crustacea, the similarity of their mandibles with certain types found in the Crustacea (especially the Cumacea), the possession of large compound eyes (absent in other groups of Apterygota), and the presence of the coxal styles on the middle and hind legs. These styles are considered to represent either a Crustacean exopodite (Hansen) or an epipodite.

Hansen's Theory appeared to receive great additional support when Folsom (1900) announced the discovery of the embryonic maxillulary or superlingual segment in the embryo of *Anurida*, one of the Collembola. Unfortunately this discovery was later on proved to be based upon a misconception, and Folsom himself withdrew his claim. The posi-

tion at the present day is that nobody has ever seen more than six primitive segments in the embryonic head of an insect. It is only fair to state that the embryology of the head of *Machilis* has not yet been fully investigated, although this is one of the insects in which the maxillulæ are best developed.

Hansen's position has been attacked in detail by Crampton (1917 *et seq.*). This author, himself a firm believer in the descent of Insects from Crustacea, is nevertheless convinced that the head of an Insect consists of only six segments, and that Hansen committed a grave error when he homologised the superlinguæ or maxillulæ of Insects with the first maxillæ or maxillulæ of Crustacea. The difference between Hansen's and Crampton's interpretations of the segmentation and appendages of the Insect head is best exhibited in tabular form (Table A).

TABLE A.

TABLE SHOWING SEGMENTATION AND APPENDAGES OF THE HEAD IN CRUSTACEA AND INSECTA ACCORDING TO (A) HANSEN, (B) CRAMPTON.

SEGMENT.	(A) APPENDAGES, HANSEN, 1893.		(B) APPENDAGES, CRAMPTON, 1922.	
	CRUSTACEA.	INSECTS.	CRUSTACEA.	INSECTS.
1.	(Compound Eyes)	(Compound Eyes)	(Compound Eyes)	(Compound Eyes)
2.	1st Antennæ	Antennæ	1st Antennæ	Antennæ
3.	2nd Antennæ	(Absent)	2nd Antennæ	(Absent)
4.	Mandibles	Mandibles	Mandibles	Mandibles
	—	—	(Paragnaths)	(Maxillulæ)
5.	1st Maxillæ	Maxillulæ	1st Maxillæ	1st Maxillæ
6.	2nd Maxillæ	1st Maxillæ	2nd Maxillæ	2nd Maxillæ
7.	1st Maxillipedes	2nd Maxillæ	—	—

It will be seen from the above that Crampton challenges Hansen's conclusions as to the nature of the insect maxillulæ, and will not allow that they are true segmental appendages at all. He severely attacked Folsom's embryological studies also. In his view, the maxillulæ of Insects are the exact homologues of the paragnaths of the higher Crustacea, which are also not considered to be true segmental appendages. It

therefore follows that the first and second maxillæ of Insects are the homologues of the first and second maxillæ of Crustacea, and the two types of head are both composed of six fused segments and are even more closely similar than Hansen imagined.

I think Crampton has proved his case very fully; and, personally, in common with almost all modern entomologists, I accept the thesis that the Insect head is composed of six segments and that the maxillulæ are homologous with the paragnaths of Crustacea. I do not agree, however, that this proves the descent of Insects from Crustacea; it only proves community of origin. One need only point out that the heads of Trilobites and of many Myriopods also have six segments to see the fallacy of Crampton's argument. Insects may, or may not, be descended from Crustacea. If they are, then a much more detailed proof of that descent is still required.

This detailed proof Crampton has attempted to supply, in a long series of papers, all directed towards the same end. He started off with the idea that the Tanaidacea, Isopoda, and Cumacea had a common ancestry with the Insecta (1920), but modified this after a fuller study of the mandibles (1922) to a theory of the descent of Insects from a common ancestor intermediate between the Mysidacea and Syncarida. His later studies appear to have attracted him more and more towards the Syncarida as the actual ancestors of Insects, and, although I have not yet received a copy of his latest paper, I understand that he now considers the Bathynellidæ to be the most probable ancestors of the Insecta.\*

It is not, of course, at all easy to deal with a theory which is still in process of modification. Let us, however, make the attempt, by instituting a detailed comparison between the Machilidæ, which are claimed to be the most primitive of all known Insecta, and the Syncarida, with a Bathynellid taken as type (figs. 5, 6).

It will be seen that Crampton's argument, as indeed all other arguments in favour of the Crustacean descent of

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\*In a more recent communication, received after this was written, Dr. Crampton further modifies his position, merely claiming that Insects are derived "from Crustaceoid ancestors." What this means actually I am not quite clear, unless his word "Crustaceoid" really means "Crustacean." It would appear to involve the abandonment of any claim that Insects are descended from any higher type of Crustacea, and the substitution of a more general claim that they are descended from a more primitive Crustacean type.—R.J.T.

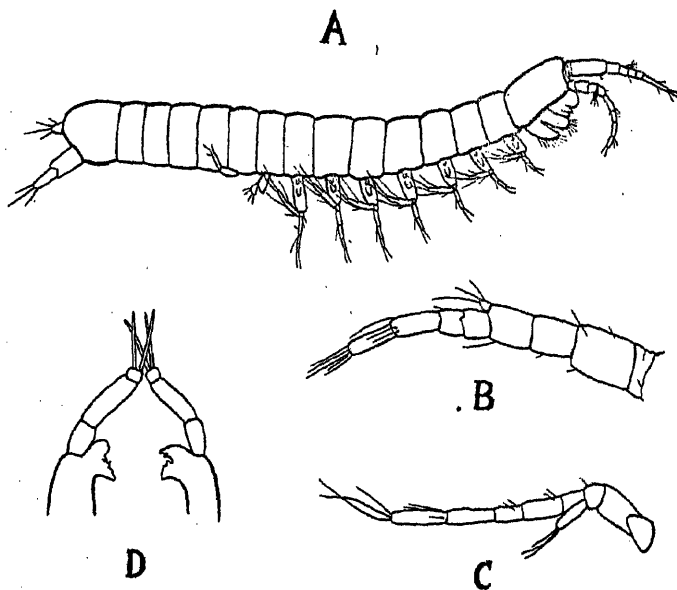


Fig. 5. *Bathynella natans*, Vejd. Class Crustacea, Order Syncarida, family Bathynellidae. A, lateral view of male; length 2mm. B, first antenna of same. C, second antenna of same. D, mandibles of same, with endopodites and incisor and molar areas. After Calman.

Insects, deals only with the exoskeleton, i.e., the segmentation and appendages. The details of embryology and the form of the various systems of internal organs are not taken into account. Here, then, I must make a definite demand, viz., that before any theory of the Crustacean ancestry of Insects can be accepted, it must indicate the lines of evolution of the Insectan type of embryology and of the Insectan types of internal systems of organs from those of Crustacea. And this demand must all the more be carefully fulfilled if, after our examination of the case based on external characters only, it appears that a Crustacean ancestry of Insects is at all probable.

Let us consider, first of all, the *segmentation* of the body. In the Syncarida we have six fused head-segments, eight thoracic segments, and six abdominal segments, plus a telson. This gives a total of twenty complete somites. For the primitive Insect, we count again six fused segments for the head, three for the thorax, and eleven for the abdomen, plus a telson; the total is again twenty. All that is

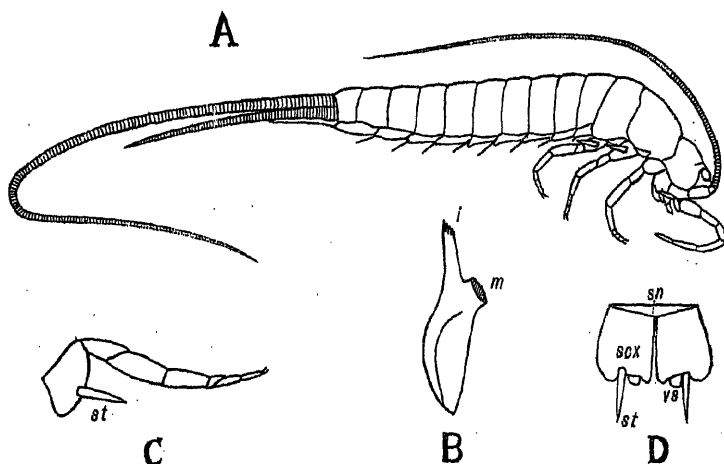


Fig. 6. *Nesonachilis maoricus*, Till. Class Insecta, Order Thysanura, family Machilidae. A, lateral view of female; length 55 mm., excluding tail-filaments. B, mandible of same, showing incisor (*i*) and molar (*m*) areas. C, middle leg of same, showing coxal style (*st*). D, fifth abdominal sternite of same, showing subcoxa (*scx*), sternum (*sn*), styles (*st*), and exsertile vesicles (*vs*).

necessary, then, for a Bathynellid to become a Machilid, as far as segmentation is concerned, is for the last five thoracic segments to change their function and become abdominal, with consequent reduction of their appendages to vestiges! It looks so simple, put thus, that one may well be tempted to ask: Where is the evidence that such a vast change as this ever took place, and where are the intermediate forms to be found? The reply to this is that the Machilidae themselves possess reduced appendages on most of their abdominal segments. Unfortunately, the Bathynellidae only possess abdominal appendages on the first and sixth segments, whereas in the Machilidae the abdominal appendages, though reduced, occur on all, or nearly all the segments. Thus, on this point alone, the Bathynellidae cannot be the ancestors of the Machilidae; and the latter, if descended at all from Syncarida, must have been derived from a form with a complete series of abdominal appendages! Here one may well interpose and ask: Why not, then, be quite logical, and derive the Machilidae from a Myriopod?

Next let us consider the appendages. The first thing that we note is that almost all Crustacea, including the Syncarida, possess *two pairs of antennae* (fig. 5, B, C). Insects



and Myriopods, on the other hand, have only the first pair. If the Machilidæ are derived directly from Bathynellidæ or any other form of Syncarida, we may ask, where is the evidence of the suppression of such a functionally active appendage as the Crustacean second antennæ? In the embryology of Insects, the intercalary segment, corresponding with the Crustacean segment bearing the second antennæ, is practically suppressed; in fact, it is only *inferred* from the composition of the embryonic brain and the presence of a pair of coelomic sacs. At no stage does it appear as a well-defined embryonic segment, and at no stage is there any sign of embryonic appendages.

We may well ask: Is it possible to believe that this can be so, if Insects are really derived directly from a high type of Crustacean in which this segment and its appendages are strongly developed both in the embryo and the adult? Why not, again, be more logical, and derive the Insects direct from more primitive terrestrial forms in which this segment and its appendages have never yet been found complete?

Our difficulties are not over with the second antennæ. We come next to the *mandibles* (figs. 5D, 6B), one of Crampton's strongest points. His work (1922) in comparing the primitive Machilid mandible with that of Crustacea has been carefully done and is of great interest. He stresses the point that the insect mandible has never, in any known form, possessed more than a single segment, corresponding with the coxopodite of a typical Crustacean limb. He then clearly differentiates the separate incisor and molar areas in the mandible of *Machilis*, and compares them with similar areas found in certain Crustacean mandibles, notably in those of *Asellus* (Isopoda), *Diastylis* (Cumacea), *Apscudes* (Tanaidacea), *Stegocephalus* (Amphipoda), etc. Curiously enough, all these mandibles, except that of the Cumacean *Diastylis*, possess well-developed endopodites, and so do the mandibles of *Bathynella* (fig. 5D) and other Syncarida, not definitely considered by Crampton in his argument. So he has either to hold that *Machilis* is descended from the Cumacea, or from some Decapod form with a similar type of mandible, or else derive them from one of the other groups by loss of the mandibular endopodite.

To all this argument one can only reply, that it *may* be so, or *may not*! Where is the proof, in insect embryology or morphology, that the insect mandible ever possessed the

original form of a complete Crustacean appendage, or even merely possessed an endopodite? I confess that I find no evidence for it anywhere. It is all purely plausible assumption. It appears to me just as logical to argue that incisor and molar areas have been differentiated in Arthropod mandibles more than once in the course of evolution. I will not deny that Crampton *may be* right; all I would say is that other explanations *may be* right also, and that he has not fully proved his case.

Crampton then deals with the first maxillæ (1922) and derives these from a complete, typical Crustacean appendage. Incidentally, one notes here that he requires three basal segments, coxopodite, basipodite, and ischiopodite, for his primitive Crustacean type, as indicated in Table B; whereas, in dealing with the mandible, he does not hesitate to demand a type with only a single basal segment, and argues that any apparent division of it is purely secondary. So the mandibular endopodite arises, according to Crampton, from the basal segment, while in the first maxilla it arises from the third!

TABLE B.

TABLE SHOWING HOMOLOGIES BETWEEN PARTS OF THE CRUSTACEAN AND INSECTAN MAXILLA (AFTER CRAMPTON).

PART.	IN CRUSTACEA.	IN INSECTA.
First or Basal Segment.	Coxopodite.	Cardo.
Second Segment.	Basipodite.	Stipes.
Its gnathobase.	(Endite)	Lacinia.
Third Segment.	Ischiopodite.	Palpifer.
Its gnathobase.	(Endite)	Galea.
Exopodite (from basipodite).	Exopodite.	Absent.
Endopodite (from ischiopodite).	Endopodite.	Palpus.

Table B shows clearly the homologies of the parts of the Crustacean and Insect maxillæ, as given by Crampton. It must be remembered that Hansen should be given the credit for pointing out the incorrectness of the idea that the maxillary palp was the Crustacean exopodite. We can agree with Crampton that the cardo and stipes of an insect maxilla correspond with the two basal segments of the Crustacean appendage, and that the exopodite is absent.

But one may reasonably doubt whether the palpifer of the insect maxilla is an original segment, seeing that it is very seldom differentiated at all in the Insects. Moreover, as nobody has ever seen even a vestige of an undoubted exopodite in any Insectan appendage, why not go at once to the root of the argument and ask: Why is it necessary at all to have to derive any insect appendage from the biramous type found in the Crustacea? Is not this begging the whole question?

The matter appears to resolve itself into this, that, granted that the insect maxilla has been derived from the Crustacean maxilla, the mode of reduction is clear. But the fact that the lacinia and galea are gnathobases does not prove that the appendage was originally of Crustacean type; it merely proves that it is a primitive appendage modified as a jaw. Unless we tacitly assume the origin of Insecta from marine types, such a primitive appendage need never have been biramous at all.

Turning next to the insect leg, we note that here again the supporters of a Crustacean ancestry would have us believe that it has been derived from a typical biramous appendage by loss of the exopodite. In this case, the coxal styles of *Machilis* have been brought into the argument and are claimed to be either exopodites, or, alternatively, epipodites of the primitive appendage, according to whether we accept the coxa as the original second segment of the insect leg or the original basal segment. In either case, we might reasonably expect it to occur on all three pairs of legs, instead of on only two, and we should certainly expect it to be present in the newly hatched larva, though this does not seem to have been determined as yet. May we not fairly ask: Is not this style perhaps merely a spur, not an exopodite or epipodite at all? Such spurs are known to occur on other segments of the legs of insects, notably the tibia; but epipodites are not known to occur at all in Insecta, with this sole possible exception. And, if these styles have any significance at all, what about the long series found in *Scolopendrella* (figs. 9, 15)?

Crampton also compares the terminal appendages of the Insecta with those of the higher Crustacea. There can be no doubt that the cerci of Insects are homologous with the uropods of Crustacea, and that both forms possess a telson. But this does not prove descent of Insects from Crustacea.

True cerci are present in the Symphyla as well as in many Insects; why should not the Insectan cerci be developed from older organs in the Myriopoda?

Fig. 7 exhibits the phylogeny of Insects and their allies, as conceived by Crampton (1920).

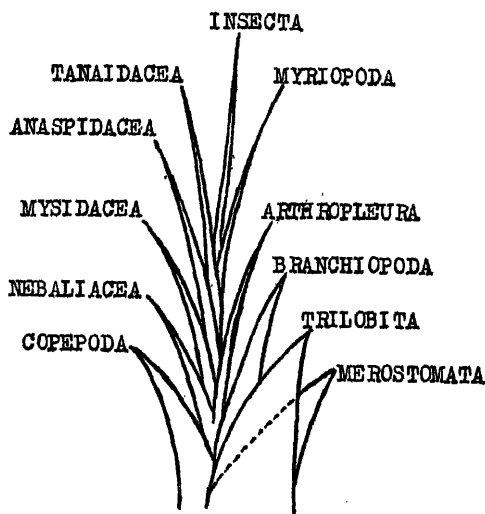


Fig. 7. Phylogeny of Insects and their nearest allies, according to Crampton (1920).

The outcome of all that Crampton has written appears to me that, *so far*, there appears to be no inherent impossibility that the Insecta may have been descended from Syncarida or some closely allied group, but that it does not appear to be very likely. We must also remember that Crampton has not made use of any characters except just those which serve his argument, and that these have all been selected from the rather narrow field of external morphology. Even within that field, we await from Crampton an explanation of the complete loss of the second antennæ in Insecta, as well as a detailed explanation of an equally bad crux, viz., how any form in which a specialisation of the postcephalic region already into a thorax with eight somites and an abdomen with six or seven could possibly be transformed into one of the Insect type! And, as I have already remarked, the more convincing Crampton can make his reply on these points, so much the more must we then demand from him additional proof of his theory by

a rigid examination of the various systems of internal organs, all of which must show a reasonable possibility of evolution from the Syncarid or allied Crustacean type to the primitive Insectan type.

As an alternative theory is being put forward later on in this paper, I need only refer the reader to the arguments there developed in connection with the embryology and the various internal organs, for him to see how impossible it is, when these are considered, for us to accept any group of Crustacea as in any way the immediate ancestors of the primitive Insecta. And, as the theory of a Crustacean origin fails badly on these points, it must be adjudged to fail altogether.

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Let us now turn our attention to those theories which seek to derive the Insects from terrestrial Arthropoda. All such theories must have one of two aims: they must either attempt to derive Insects from Myriopoda, or they must go farther back and attempt to derive both insects and Myriopods through a common ancestor from the Onychophora. We may therefore classify them as follows:—

III. The General Theory of the Terrestrial Origin of Arthropoda—*Versluys' Theory*.

IV. The Theory of Descent of Insects from Myriopoda—*Brauer's Campodea Theory*.

### III. VERSLUYS' THEORY.

This very interesting theory has been set forth in much detail in a series of papers by Versluys and Demoll (1914-1922). Though it is primarily concerned with the evolution of the Arachnida, it has to be taken account of as an important theory which bears on the possible line of evolution of Insects. For that reason I propose to give a short account of it here and to offer some criticisms.

The theory starts off with the well-known thesis of Ray Lankester (1881) that *Limulus* is a marine Arachnid. Ever since Ray Lankester propounded that thesis, it has been universally accepted that *Limulus* is a true Arachnid and a remnant of the otherwise extinct group of Merostomata, to which the Palæozoic fossil Eurypterids belonged. It has also been fairly generally accepted that the marine fossil groups, Eurypterids and Trilobites, were the ancestral forms of all the principal groups of Arthropoda, leaving

*Peripatus* out of account. In particular, the Scorpions and their allies are held to be terrestrial descendants of marine Arachnid ancestors, and the old group Tracheata, which was formed to include all the tracheate air-breathing Arthropods, is now believed to have no foundation as a monophyletic group.

The above statement is, I think, a fair summary of the orthodox view held by most zoologists since Ray Lankester published his theory.

Now Versluys and his colleague contest this view. They are in entire agreement with Ray Lankester concerning the Arachnid affinities of *Limulus* and the Eurypterids; but they hold that the deduction that the terrestrial Arachnids are descended from marine forms is entirely wrong, and that, on the contrary, these huge marine types are themselves specialised offshoots from more primitive terrestrial forms allied to the Scorpions. This conclusion is come to by an interesting series of deductions, as follows:—

- (a) An analysis of the external characters of Scorpions and Eurypterids indicates that they were very closely allied.
- (b) But even more primitive forms than Scorpions still live on the land, e.g., the Palpigradi, the Solifugæ, and the Chernetidea, in which the thorax has two free segments and the differentiation between pre- and post-abdomen is not so marked.
- (c) Also a careful study of the structure of the eyes of *Limulus* and Scorpions indicates that the former must have been derived from the latter, not *vice versa*; i.e., the change in form must have been preceded by a change of living, from air to sea-water, and not *vice versa*.
- (d) In general, the appendages of Eurypterids and *Limulus* are more specialised than those of Scorpions, and their respiratory appendages are nothing more than slightly modified sternites.

As far as this argument goes, I believe Versluys has made out a good case. But he now takes another very big step. It being proved that the Arachnida were originally terrestrial tracheate forms, he now goes on to trace them back to a common ancestor with the Progoneate Myriopods, on

the ground of the forward position of the genital opening, common to both groups. As the Arachnida never developed true mandibular jaws, of the type found in Myriopods and Insects, this conclusion involves also the branching-off of the Arachnida from the ancestral terrestrial tracheate stem at a period earlier than the evolution of the true Progoneate Myriopods. This clearly involves the derivation of the three groups, Arachnida, Myriopoda, and Insecta, from an exceedingly primitive type of terrestrial tracheate Arthropod. Such primitive ancestral group, according to Versluys, can be nothing else than the Onychophora! Incidentally, the unity of the old group Tracheata is affirmed, and all living Arthropods must be derived from it!

Versluys also holds that organs like the compound eye, the chelicerae, and the compound or segmented fore-brain can only have arisen once in each case. So the present-day Peripatoids are the remnant of the original tracheate stem, before any of these organs were formed. Then arose, as a specialisation from the Onychophora, exceedingly primitive Myriopod types, both progoneate and opisthogoneate. One side-branch of the progoneate forms developed chelicerae and gave origin to all known Arachnida, including the Pycnogonida. The main stem went on and developed a more complex fore-brain. Before the compound eye was formed, most of the existing Myriopod groups branched off from it. Then came the highest groups of all, with the compound eyes well formed. Of these, the highest expression is the Insecta, while the Trilobites and Crustacea are much more primitive side-branches that took to the sea!

The above phylogeny can be graphically expressed as in fig. 8. Incidentally, I would like you to note that the portion of Versluys' Theory which deals with the Insects is a kind of inversion of Handlirsch's and Crampton's Theories, in so far as he would derive both Trilobites and Crustacea from a terrestrial ancestor preceding Insects and Myriopods.

In considering the evolution of Insects, I do not feel called upon to criticise very fully that portion of Versluys' Theory which deals with the Arachnida. I can only say that his papers are well worth reading for the wealth of detailed study of primitive Arachnid types contained in them. But we must join issue on those main points which lie outside his survey of the Arachnida, viz., on the unity of the old group Tracheata, on the monophyletic origin of vari-

ous complex organs, and on the derivation of Trilobites and Crustacea from terrestrial forms. Let me briefly indicate my main criticisms:—

(1) *The Tracheata*.—I consider that Versluys' main theory could well stand by itself, without seeking to bolster up this old, discarded group. If we follow the Insects back to the most primitive forms, we come to a few simple types in

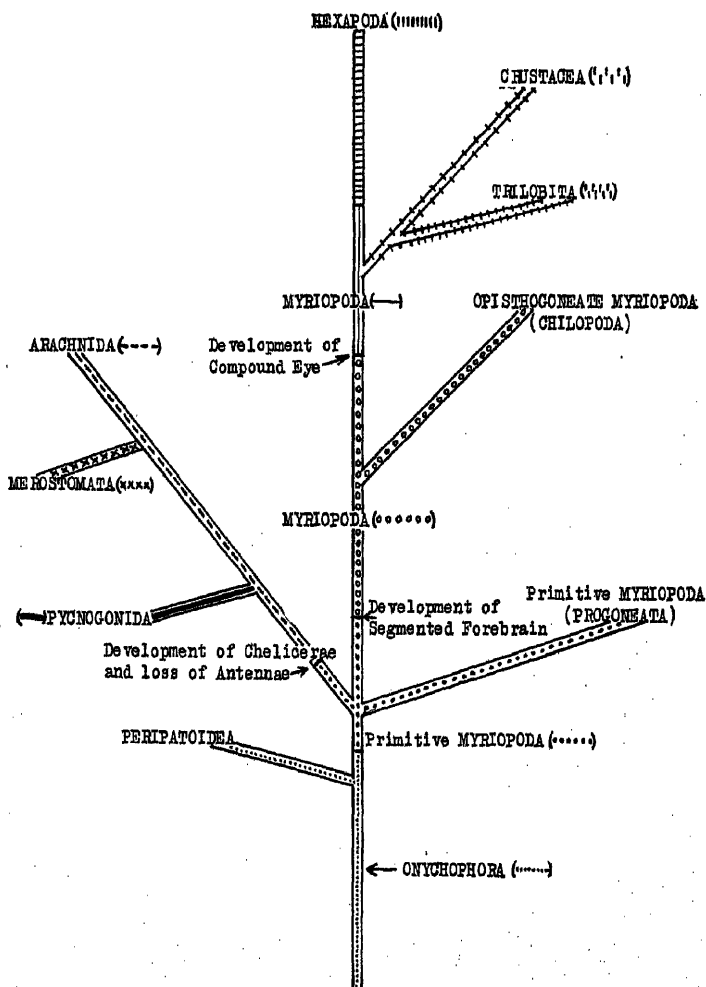


Fig. 8. Phylogeny of the Arthropoda, according to Versluys (1928, *in litt.*).



which no tracheæ are developed. How do such forms breathe? Obviously, through their integument. The formation of a tracheal system was, in the first instance, an attempt to increase the respiratory surface of the integument at those points where it was already most permeable. The same is true of the Myriopoda. Why, then, should we demand a tracheate common ancestor for all terrestrial forms of Arthropoda? Is not the structure of the tracheal system in *Peripatus* an eloquent witness to this very thing? How could the various tracheal systems of Onychophora, Myriopoda, Insecta, and terrestrial Arachnids have arisen, unless we grant a common ancestor that breathed through the integument only?

I would go so far as to say that it is no more necessary to insist on a common tracheate ancestor for all terrestrial Arthropods than it is to insist on a common gill-bearing ancestor for all marine forms.

(2) *The Compound Eye*:—It seems certain that this organ was originally formed from an aggregation of separate simple eyes. The fact that many of the larger types of Chilopods possess such assemblages of eyes on each side of the head should make it a matter of little surprise to us that in one group, the Schizotarsia, true compound eyes of the type found in Insects occur. In this and other characters there can be no doubt whatever that *Scutigera* and its allies are very highly specialised Chilopods. This, however, does not mean that *Scutigera* lies anywhere along the line of evolution of the Insects, nor of the Crustacea, nor of the Trilobites. Though the detailed structure of the compound eyes of Insects and Crustacea is extraordinarily similar, I fail to see myself why two such similar structures should not have arisen independently, given that the original elements, the simple eyes, were being developed over and over again in more primitive groups. The fact that the most primitive compound eye in Crustacea was almost certainly of the stalked type seems to rule out entirely a monophyletic origin for these organs in Insects and Crustacea; for compound eyes in Insects are without exception sessile. But the same fact does not preclude the derivation of the Crustacean stalked eye from the Trilobite eye, since the position of the latter on the free cheek would appear to be exceptionally favourable to the development of a stalked type.

It seems reasonable to conclude that compound eyes arose on four separate occasions during the evolution of the Arthropoda—

- (a) in the Arachnida;
- (b) in the Trilobite-Crustacean ancestor;
- (c) in the Schizotarsia; and
- (d) in the Insecta.

(3) *The descent of Trilobites and Crustacea from a terrestrial common ancestor with the Insects and Myriopoda:*—I do not propose to refute this in detail, because Professor Versluys himself, in a carefully reasoned statement setting forth the main points of his theory, and sent to me with permission to publish it, agrees that his “hypothetical evolution” is still unsatisfactory as regards its treatment of the Insecta and Crustacea. He explicitly mentions that he has not yet overcome the difficulty of accounting for the presence of two pairs of antennæ in the Crustacea against only one in Insects and Myriopods, and also how the genital openings in Crustacea and Insects came to be so differently placed.

I think we can conclude that Versluys’ Theory, interesting as it is in regard to the evolution of the Arachnida, does not give us the proof that we are searching for about the origin of Insects. It is chiefly presented here as an offset to Handlirsch’s and Crampton’s theories, of which it is, as regards the evolution of Insects, the very antithesis.

#### IV. THE DESCENT OF INSECTS FROM MYRIOPODA.

From very early times there has existed a not very clearly defined belief in the descent of Insects from Myriopods. The first clear direction was given by Brauer (1869-70) in his well-known Campodea Theory. Brauer claimed that all living insects were descended from a type very similar to the existing genus *Campodea* in the Order *Thysanura*, and that this type was still preserved in many primitive larval forms of winged insects; these forms he termed *campodeiform* larvæ. The Campodea-type was derivable from the Chilopoda, and these latter in their turn from Onychophora.

Brauer’s theory of the primitiveness of the campodeiform type of insect larva has been widely accepted, but his derivation of Insecta from Chilopoda has met with little or no support.

Packard (1898) saw clearly that Insects could not be derived either from Diplopoda or Chilopoda, though he held that the latter were the nearest large group of Arthropoda to the true Insecta.

Brauer's theory led to a search by many authors for relatives of *Campodea* outside the Insecta, and thus brought the Symphyla into the question. Thus a school of writers arose who claimed that *Scolopendrella* and *Campodea* (figs. 9, 10) were very closely related. Amongst these we may mention Packard, Ryder, Grassi, Haase, and Pocock. The last-named (1893) elevated the Symphyla to the position of an independent Class, and claimed that it was the "living

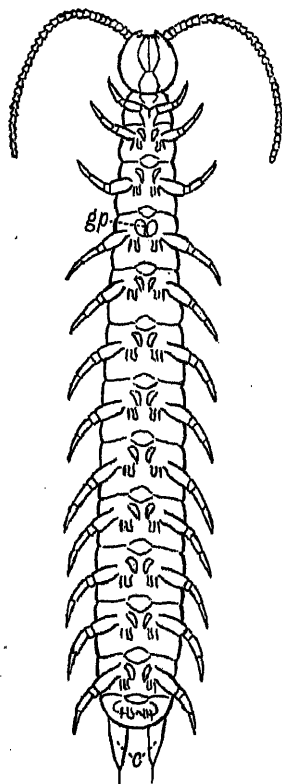


Fig. 9. *Scolopendrella* sp., Australia. Class Progoneata, Order Symphyla, family Scolopendrellidae. Length 6 mm. Ventral view, showing cerci (c) and gonopores (gp). Note the presence of styles and exsertile vesicles on most of the abdominal segments.

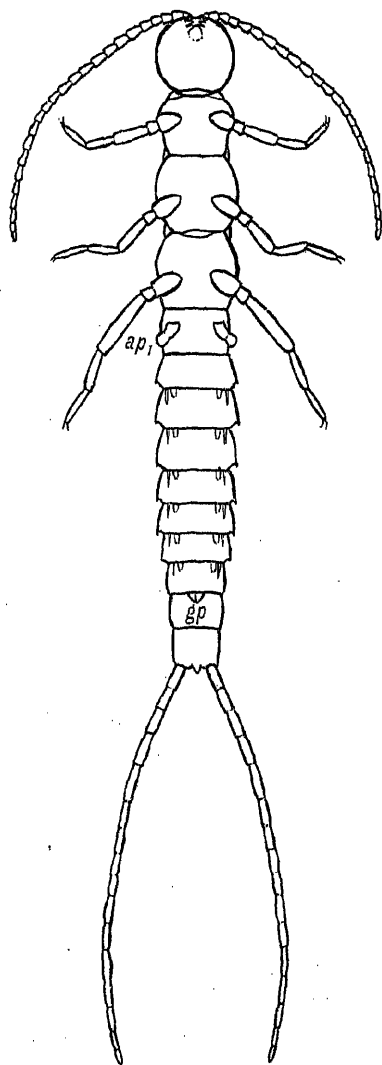


Fig. 10. *Campodea philpotti*, Till. Class Insecta, Order Thysanura, family Campodeidae. Length 7 mm, excluding cerci. Ventral view, showing appendages of first abdominal segment (*ap 1*) and gonopore (*gp*). Note the presence of styles and exsertile vesicles on some of the abdominal segments, also the long, many-segmented cerci.

"form that comes nearest to the hypothetical ancestor of the "two great divisions of tracheates," i.e., of Myriopods and Insects. Thus all previous nebulous ideas as to the derivation of Insects from Myriopods became crystallised in this single theory. It is true that Pocock himself held that both Myriopods and Insects had descended from *Scolopendrella*. Packard strongly combated this view; he held that *Scolopendrella* was a remnant of an otherwise extinct group from which the Insects had descended, and which partially filled the wide gap between *Peripatus* and the Insects. Schmidt (1895) put the Symphyla between the Diplopods and the Pauropods, thus removing them further from the Insects. Packard recognises the difficulty created by the fact that the Symphyla are progoneate while the Insects are opisthgoneate, but he does not consider that sufficient to overthrow the theory.

Let us now consider a number of points for and against the theory:—

- (1) The general form of the head in *Scolopendrella* closely resembles that of *Campodea*; in particular, the Y-shaped suture which separates the epicranium from the frons in many primitive insects is present in *Scolopendrella*.
- (2) The antennæ are elongated, many-segmented and moniliform, thus differing from those of any other Myriopoda and very closely resembling the antennæ of *Campodea*.
- (3) There are two pairs of maxillæ present, as in Insects, though other groups of Progoneata (Diplopods, Pauropods) apparently possess only one.\*
- (4) All the legs except the first pair are four-segmented, and the tibio-tarsus ends in a claw plus an empodium. Thus they closely resemble the legs of Collembola, though they are of more primitive type in lacking the marked differentiation of femur and tibia.
- (5) At the base of each leg there is a movable style (fig. 15, *st*) and, alongside this, an eversible ventral sac (fig. 15, *vs*). Though the abdominal legs are absent in the Thysanura, movable styles and ventral sacs occur throughout that group of In-

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\*G. H. Carpenter (1905), however, maintains that *Polyzenus*, a primitive Diplopod, has two pairs.

sects on a varying number of abdominal segments (figs. 6, 10, 12, *st*, *vs*).

- (6) The last segment of the abdomen carries a pair of unsegmented cerci (fig. 9, *c*). Similar organs occur in all the Thysanura, and they are unsegmented in the Japygidæ.
- (7) Malpighian tubules are present, two in number, and open into the anterior end of the hind-gut, as in Insects generally.
- (8) The tracheal system opens by a single pair of stigmata situated in the head. Although *Campodea* itself has only thoracic spiracles, the Collembolan family Sminthuridæ has a pair of head tracheæ only.
- (9) The alimentary canal resembles that of *Campodea* closely, and rectal glands are present.
- (10) A pair of anal glands open at the tips of the cerci (fig. 9, *gl*). Similar glands occur in the Thysanuran *Anajapyx* (fig. 12 *gl*).

This is a formidable list of resemblances. Let us now consider the differences:—

- (1) The mandibles are two-segmented. No known insect has this primitive character.
- (2) The tergites and sternites of the body-region do not coincide. There are apparently only thirteen sternites, twelve bearing legs and the thirteenth being the anal segment. The number of tergal plates is fifteen or sixteen.
- (3) The gonoducts are directed forward and open into a pair of closely opposed gonopores placed on a raised median area on the fourth abdominal sternite (fig. 9, *gp*).

With regard to the above three characters, in which the Symphyla differ markedly from the Insecta, I would say that the possession of two-segmented mandibles need not surprise us in so primitive a form. Nor does such a character necessarily remove its possessor from being considered as a direct ancestor of Insects. The lack of agreement between tergites and sternites is, perhaps, of less importance than appears at first sight; for we have to remember that we do not yet know anything about the embryology of the Sym-

phyla, and it may well be that a sternite without legs has become suppressed near the head end, while it seems highly probable that the original embryonic anal segment never carried legs (*cf.* the Pauropoda) and so the supposed last segment may be in reality two. This would bring the total number of abdominal segments up to fifteen for both sternites and tergites, which is exactly the number obtained by adding the number of thoracic and abdominal segments in the Protura. But the third character, the progoneate position of the genital opening, remains still a bad stumbling block, and it is on this character that the theory of the origin of Insecta from Symphyla goes to pieces. It is, I think, fairly safe to say that, but for this one serious fault, there has never been presented any theory of the origin of insects having so many definite points in its favour.

Though there has been a marked tendency amongst many modern entomologists to turn away from the Myriopoda as possible ancestors of the Insecta, we may note that Silvestri (1901-9) has brought a fresh interest into the problem by the study of his new family Projapygidæ, and particularly by his detailed account of the genus *Anajapyx* (fig. 12), which should be compared with the Japygidæ also (fig. 11). This extraordinary insect appears to come even closer to the Symphyla than does *Campodea*. The cerci are short and only divided into a small number of segments, thus bridging the gap between the type found in *Campodea* on the one hand and the type found in *Scolopendrella* on the other. Further, a pair of anal glands are developed exactly as in *Scolopendrella* and open at the tips of the cerci. Thus, in spite of the difficulty that still remains, and to many still appears insuperable, regarding the progoneate position of the genital openings in the Symphyla, one may say that new interest has been aroused in this old theory, even though the final proof of descent is still lacking.

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Our survey of the main theories has now brought us to the position that no fully acceptable theory of the evolution of the Class Insecta has yet been presented. We may say that Handlirsch's Theory attracts many because of the brilliance and lucidity of its presentation; that Crampton's Theory, in spite of some excellent points, has not been clearly presented and fails to make a strong appeal; that

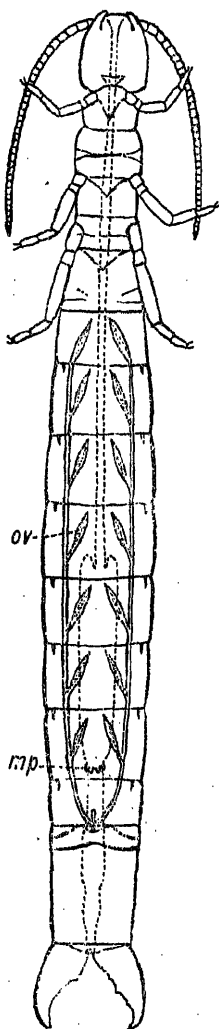


Fig. 11. *Heterojapyx gallardi*, Till. Class Insecta, Order Thysanura, family Japygidae. Length 40 mm. Diagrammatic ventral view of female, with the reproductive system consisting of seven pairs of segmentally arranged ovaries (ov). Alimentary system shown by means of dotted lines; the small Malpighian tubules are shown at mp. Note the unsegmented forceps-like cerci (cf. those of *Scolopendrella*, fig. 9), the position of the gonopore, and the presence of styles on some of the abdominal segments.



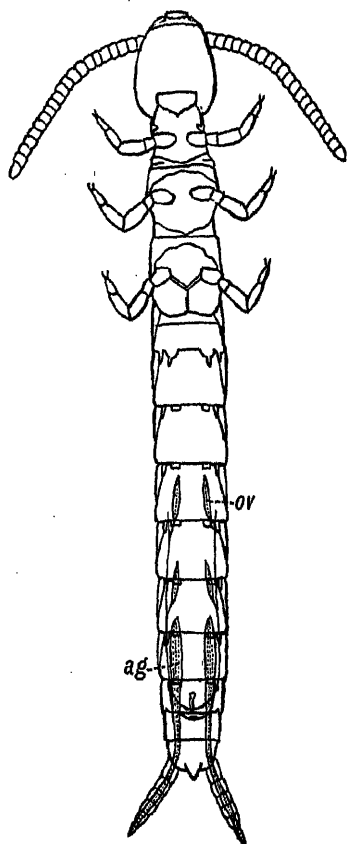


Fig. 12. *Anajapyx vesticulosus*, Silv. Class Insecta, Order Thysanura, family Projapygidae. Length 2 mm. Diagrammatic ventral view of female, with reproductive system consisting of two pairs of ovaries (ov). The anal glands (ag) are shown with their ducts opening at the ends of the cerci (cf. *Scolopendrella*, fig. 9). Note the appendages of the first abdominal segment (cf. *Campodea*, fig. 10), also the styles and exsertile vesicles on the following segments. After Silvestri.

Versluys' Theory has not been given any particular attention by entomologists; and, finally, that probably the most attractive theory of all, viz., the origin of Insects from a common stock with the Symphyla, has fallen to the ground owing to the apparently insuperable difficulty of explaining the differences in the position of the genital openings. The final verdict on all these theories must be "Not Proven."

## SECTION II.

## A NEW THEORY OF THE DESCENT OF THE CLASS INSECTA.

We are now in a position to ask: Do we know enough about the Arthropoda in general, and about primitive insects in particular, to attempt to construct any theory concerning the descent of the Class Insecta which might be acceptable to modern entomologists? I think we do; but we must be prepared to take a somewhat wider view of the problem than has hitherto been the case.

To my mind, a theory of the Evolution of the Insecta, to be acceptable, must satisfy the following conditions:—

- (1) It must indicate, without any wide break, the line of evolution followed, not only by the external form, segmentation and appendages, but also by the various internal organs;
- (2) It must also indicate the way by which the very highly specialised type of embryological development found in the Insecta has been attained; and
- (3) It must account for the “aberrant” primitive groups of Insecta, viz., the Collembola and Protura, as well as showing the line of evolution leading to the Thysanura and the Pterygota.

Let us, then, first of all ask: On what acceptable foundation are we to base our new theory?

The following points appear to me to be a sound basis to work upon:—

- (1) *The Apterygota are not descended from originally winged forms, but are more primitive than the Pterygota.* All theories of descent for the Insecta admit this, except Handlirsch's. In view of the recent discovery of Collembola in the lower Devonian peat-bogs, can we any longer doubt that Handlirsch is here in error?
- (2) *The Thysanura Ectotrophica are the immediate ancestors of all Pterygote insects.*
- (3) *The Thysanura Entotrophica are closely related to the Thysanura Ectotrophica, and therefore very close to the main evolutionary stem of the Pterygota.*

- (4) *The Collembola and Protura are much further removed from the Pterygota than are the Thysanura.*

Those who would now follow me into the details of my new theory are asked to accept these four main propositions, if not as self-evident axioms, at any rate as so soundly based that they may be taken as the groundwork of our theory.

It follows from these four points that we shall nowhere be concerned in this theory with the origin of wings or of winged insects. What we are concerned with is the inter-relationship of the three great groups of Apterygota, viz., the Collembola, the Protura, and the Thysanura, and the nature of their common ancestors. I take leave to think that this subject is wide enough for the founding of a sound theory, and that it is also of the most intense interest to all entomologists.

In working out the details of my theory, I must, perforce, begin with the more obvious arguments involving the comparative morphology of known forms. These will, however, be extended to include a survey of the evolution of the chief internal organs and of the embryology, and due regard will be paid to the principle that no violence must be done to the known geological record, imperfect as it may actually be. Further, the ontogenetic stages indicated in the various larval changes will be given due consideration.

#### SEGMENTATION AND THE SEGMENTAL APPENDAGES.

T. H. Huxley (1859) once remarked—"I venture to think it a matter of no small moment if it can be proved that a Lobster, a Cockroach, and a Scorpion are composed of the same number of primitive somites." He did not, however, as some think, actually call attention to the existence of such a correspondence. Let us grant at once that, if this correspondence actually does exist, then momentous conclusions must flow from it. Ray Lankester (1904) and G. H. Carpenter (1905) have followed this line of argument up, and the latter author presents a table showing the numerical correspondence of segmentation in all the chief groups of Arthropoda.

In making this comparison, Carpenter finds that the Leptostraca are the Crustacean group which agrees exactly

in segmentation with the primitive Insect, and assigns twenty-two somites to each. He also assigns the same number of somites to the Symphyla, the genus *Polyxenus* amongst the Diplopoda, and to the Scorpions, and *Limulus* amongst the Arachnida. For the Onychophora, the Trilobites, and the Branchiopoda amongst Crustacea the number of somites is highly variable; this he regards as a secondary character. The Chilopoda also have an excessive segmentation, and the primitive genus *Lithobius* is credited with twenty-four somites, the minimum for the Class. The Malacostraca amongst the Crustacea fall one segment short of the requisite number for Insects and Leptostraca; this is explained by a fusion of the original sixth and seventh abdominal somites.

Carpenter presents an attractive case. If it were fully proved, there could be nothing for it but to accept the number of twenty-two somites as the ancestral condition for the whole Phylum Arthropoda, and therefore to regard such groups as the Tardigrada, the Pycnogonida, the Pauropoda, and the Collembola as greatly reduced forms.

But there are grave weaknesses in Carpenter's thesis. First of all, he has followed Hansen in accepting seven somites for the head region in Insecta, Symphyla, and Diplopoda, by regarding the superlinguæ or so-called maxillulæ as the paired appendages of a definite somite. I think there can be no doubt that Cranpton is correct in his claim that these organs are the homologues of the paragnaths of the higher Crustacea, and that therefore the head in Insects and Symphyla is only composed of six segments. This brings the insect head into agreement with that of the Trilobites and Crustacea in general; but, at the same time, it throws out of gear the correspondence with the Leptostraca, which are now seen to possess one more somite than the Insects and Symphyla. Further, it does not appear that Carpenter has paid attention to the inequality in number of tergites and sternites in the Symphyla. Before it can be definitely asserted that this group has the same number of somites as the Insects, we must know something about the formation of its embryonic somites. Such knowledge is still completely lacking.

We are thus faced with the position that the supposed proof of the existence of an original number of somites common to the whole Arthropod stock appears somewhat forced,

and we are no longer at all bound to accept it or to incorporate it in any theory of the evolution of the Class Insecta. We may, however, still allow a considerable degree of importance to the very close correspondence in segmentation between the Malacostraca, the typical Insecta, and perhaps the Symphyla, as indicating the possibility, though by no means the certainty, that these three groups may have been descended from a common ancestor.

In developing my new theory, I propose to examine this problem of segmentation from an entirely different viewpoint. We know that all Crustacea pass through a *Nauplius*-stage, either as a free-swimming larva, or within the embryo. It is by now generally agreed that the universal occurrence of such a stage in the Crustacea is a record, preserved in the ontogeny, of the phylogenetic fact that, at some period in their past history, the Crustacea had an ancestor which is now represented in a modified form by the *Nauplius* larva. The chief modifications, of course, must be connected with larval existence, viz., small size, lack of development of certain organs not needed for larval life (e.g., the reproductive system), probable secondary reduction of the number of postcephalic somites, and also possible specialisations of certain organs, e.g., the appendages, suitable for the modified conditions of larval life. Making due allowance for all these, one can scarcely resist the conclusion that what we may call the *Nauplioid ancestor* of the Crustacea was essentially a simpler type of Arthropod than any existing Crustacean, and that it had a simpler segmentation, with fewer somites both in the head and in the postcephalic region.

Although the other marine groups of Arthropoda do not possess a definite *Nauplius*-larva, they possess evidence in their ontogenies leading to the same conclusion as the above. The Trilobites went through a succession of larval stages in which the number of segments was increased from stage to stage, and the earliest of these was most like the *Nauplius*-larva of the Crustacea. The Merostomata, as exemplified by *Limulus*, also go through a larval stage called the "Trilobite-larva," from which the adult form is reached by addition of further somites.

Further, there are a few of the more highly evolved forms amongst the Crustacea in which the whole of the original larval history is, so to speak, telescoped into the em-

bryonic period, so that they hatch out from the egg as a small edition of the adult form. Examples of this are to be found in the Crayfishes and also in the Syncarida.

Now when we turn to the terrestrial Arthropoda (leaving out of account for the present the Onychophora), we do not find any evidence of the existence of a Nauplioid ancestral type, but we do find clear evidence of the evolution of these types from ancestors which had simpler segmentation. This is most clearly seen in the Myriopoda. In this great group, all the Progoneate forms, viz., the Diplopoda, the Pauropoda, and the Symphyla, pass through a series of larval stages with gradual addition of somites. It is to be noted that the segments are not added to the posterior end of the body, but are interpolated between either the anal segment and the one originally before it (as in Diplopoda) or between the preanal segment and the one before it (as in Pauropoda), and that they may be added either singly or in groups, as many as five at a time in forms like *Julus* with many segments. This phenomenon is called *anamorphosis*, and I wish to direct attention to it here as of great importance in our new theory. In the Opisthogoneata, the Schizotarsia and a number of the Chilopoda are also anamorphic.

Contrasted with these numerous anamorphic forms, we find a certain number only of the Chilopoda in which, as in the Crayfishes and Syncarida, the whole of the larval development is telescoped into the embryonic period, and the young larva emerges with the full number of segments proper to the adult. This phenomenon is called *epimorphosis*.

Now it seems clear to me that, if we accept the fact that all Crustacea have been evolved from a Nauplioid ancestor, we must *a fortiori* accept the fact that all Myriopoda have also been evolved from a simpler ancestral type with fewer original somites.

One sees no escape from this conclusion, particularly when one studies a primitive group of Myriopoda like the Pauropoda (fig. 13), in which the adult number of somites is considerably less than is found in other groups. If there were any truth, for instance, in the fundamental proposition of Carpenter, that the original ancestor of all Arthropoda possessed twenty-two (or shall we say, following Crampton's modification, twenty-one?) somites, then some record of this reduction should be preserved in the ontogeny of the

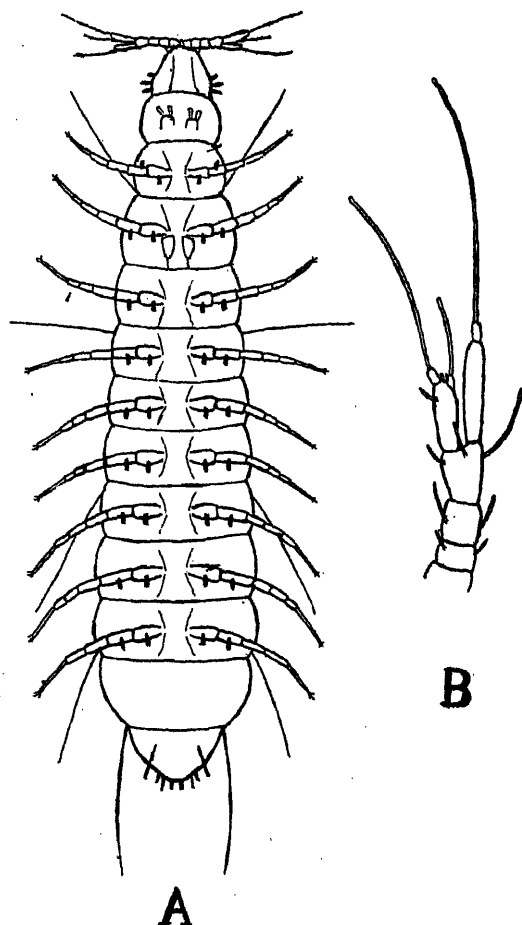


Fig. 13. *Pauropus amicus*, L. Harr. Class Progoneata, Order Pauropoda, family Pauropodidae. Length 1.6 mm. A, ventral view; length 1.6 mm. B, antenna. After L. Harrison (1914).

Pauropoda! So far is this from being the case that the Pauropoda are not even epimorphic, but just as anamorphic in their development as any genus of Diplopoda with abundant segmentation. We owe to L. Harrison (1914) a clear account of the larval stages of Pauropoda. An analysis of his paper made by me for the purposes of this argument gives us the following Table, which is highly instructive:—

TABLE C.

ANALYSIS OF THE SEGMENTATION IN THE ONTOGENETIC STAGES  
OF THE PAUROPODA.

SEGMENT.	Hexapod Larva.	10-Legged Larva.	12-Legged Larva.	16-Legged Larva.	Adult or Imago.
Head.	1. Oc.	Oc.	Oc.	Oc.	Oc.
	2. Ant.	Ant.	Ant.	Ant.	Ant.
	3. —	—	—	—	—
	4. Md.	Md.	Md.	Md.	Md.
	5. Mxl.	Mxl.	Mxl.	Mxl.	Mxl.
6.	{ —	{ —	{ —	{ —	{ —
7.	{ 1st Legs	{ 1st Legs	{ 1st Legs	{ 1st Legs	{ 1st Legs
8.	{ 2nd Legs	{ 2nd Legs	{ 2nd Legs	{ 2nd Legs	{ 2nd Legs
9.	{ 3rd Legs	{ 3rd Legs	{ 3rd Legs	{ 3rd Legs	{ 3rd Legs
10.	—	—	—	—	{ 4th Legs
11.	—	—	—	{ 4th Legs	{ 5th Legs
12.	—	—	—	{ 5th Legs	{ 6th Legs
13.	—	—	{ 4th Legs	{ 6th Legs	{ 7th Legs
14.	—	{ 4th Legs	{ 5th Legs	{ 7th Legs	{ 8th Legs
15.	—	{ 5th Legs	{ 6th Legs	{ 8th Legs	{ 9th Legs
16.	{ Preanal	{ Preanal	{ Preanal	{ Preanal	{ Preanal
17.	{ Anal	{ Anal	{ Anal	{ Anal	{ Anal

It will be seen that the young Pauropod hatches out as a six-legged larva having a total of only six somites behind the head. We must be careful not to jump to the conclusion that this larva represents an *insectan* stage in the ancestry of Pauropoda. That this is not so will be gathered at once from the fact that the first body-segment does not carry legs. Thus the legs of the young Pauropod larva are not homologous with the thoracic legs of the Insecta, but are on the second, third, and fourth postcephalic segments instead of on the first, second, and third. We may also recall that the young Diplopod hatches out as a larval form having three pairs of legs, but that these are usually on the first, third, and fourth segments, thus differing in arrangement both from the Pauropod and the Insect types.

It will, therefore, be clear that we may not claim, from this larval development, that either Diplopoda or Pauropoda



have passed through a Hexapod or Insectan stage in their ancestry. All we may claim is that they have passed through an ancestral stage with fewer somites and fewer pairs of appendages than they now possess, and that a reduction of this original number of appendages, whatever it may have been, to three pairs in the first larval stage has been accomplished in several different ways, evidently because the small first instar larval form could best get along with three pairs, though not necessarily the *same* three pairs.

Now let us try to get some idea of what this primitive ancestor was like.

In the *Nauplius*-larva of the Crustacea, the head is well-formed, and consists of four segments, viz., the ocular, the first antennal, the second antennal, and the mandibular. Three of these are preoral and one postoral. In the passage to the *Metanauplius*-larva, there is a zone of addition behind the mandibular segment, as well as a zone of addition at the posterior end of the body.

Now it seems to me that the correct interpretation to put on this is that, whatever number of postcephalic segments there may have been present in the original ancestor of the Crustacea, there can be no doubt that the head originally possessed only four segments. Thus there can only have been one pair of jaws, and the mouth must have been closed from below by a flap or process of the mandibular segment.\*

If we now compare this Nauplioid condition of the ancestral Crustacean head with the head of *Peripatus*, we find a close similarity. The ocular segment is the same in both. The second segment in *Peripatus* carries the antennæ, which are homologous with the first antennæ of Crustacea. The third segment in *Peripatus* carries the jaws, which are homologous with the second antennæ of Crustacea; and the fourth segment carries the oral papillæ, which are the homologues of the Crustacean mandibles. No true appendages close the mouth from below, but the orifice is protected by papilliform ridges.

It is here that I wish to introduce the first point in my theory which I think is entirely new, viz., that the so-called maxillulæ or superlinguæ of Insects, together with their median process the hypopharynx, and the paragnaths

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\*The presence of the *mandibular grooves* on the heads of many Crustacea, including Syncarida, may also be evidence in favour of this.

of the Crustacea, are not only *not true appendages*, but *represent definitely the ancestral lower lip of the mouth when the head was in the four-segmented condition*. I can see no other reason for their existence, from the point of view of evolution, nor can I find any other explanation of their embryonic development from the mandibular somite. They are certainly not original portions of the mandibles, budded off; for their rudiments appear separately and between the bases of the rudiments of the mandibles. If we accept this solution, we are able to understand at once the present condition of the mouth in the Insecta and Crustacea. It has evidently been enlarged by the subsequent addition of two more pairs of appendages. In the Insecta, the paired glands of the second maxillæ must originally have opened on to the exterior, beneath the head. Their ducts have now been forced up into a position apparently within the mouth, and function as salivary glands; but the fact that they open below and not above the hypopharynx is an indication that they did not originally belong to the mouth at all.

If the above interpretation is correct, one might also venture on a prophecy:—Somewhere in the Pre-Cambrian rocks there must exist an ancestor of Trilobites and Crustacea, and probably of Eurypterids also, in which the head was composed of only four segments, as in the Onychophora. This ancestor may quite well be much larger than *Peripatus*, though, in my opinion, it will probably exhibit appendages composed of only a single segment. I believe that remains of such an ancestor are already being unearthed near Adelaide; but they are in such ancient rocks and have undergone so much contortion that they will be very difficult to interpret.

Returning now to the question of the segmentation of the postcephalic region in our ancestral form, it is clear that we have no definite evidence in favour of any fixed number of segments. I would be content to claim that Arthropods in general have been descended from forms with fewer segments than are to be found in the adults of higher groups to-day, without specifying the exact number. If we again study our Pauropod Table (Table C), we see that the adult Pauropod has a total of *twelve* postcephalic somites. To reach this condition it has to pass through larval stages with successively six, eight, nine, and eleven postcephalic somites. In the Symphyla, a larval stage with six pairs

of legs is known, but the full larval history has not yet been worked out.

Let us now summarise the above results with a view to a further application of them to the problem of insect ancestry:—

- (1) In marine Arthropoda, forms with free-living larval stages are more primitive than forms that hatch with the full number of adult somites. A Nauplioid ancestor is indicated, with fewer somites than in recent dominant groups.
- (2) In terrestrial Arthropoda, anamorphic forms are more primitive than epimorphic. Again, an ancestor with fewer somites is indicated, but not necessarily a Hexapod ancestor.
- (3) In cephalisation, a stage with the head composed of only four fused segments was reached very early in the evolution of the Arthropoda. Amongst terrestrial Arthropoda, the Onychophora are a relict of this stage of evolution, though they are specialised in having attained an epimorphic development and in possessing a large though indeterminate number of postcephalic somites.
- (4) During the four-segmented head stage of Arthropoda, the paragnaths, or, alternatively, the superlinguæ and hypopharynx, were developed as a non-appendicular lower lip to the mouth, closing it from below. They belong to the last of the four then existing head-segments, i.e., the mandibular.
- (5) Later evolution of the head-capsule produced either five-segmented heads (Diplopoda, Pauropoda), or six-segmented heads (Trilobites, Crustacea, Chilopoda, Insecta). In such cases the mouth-cavity became enlarged and closed below by the maxillæ or labium, so that the hypopharynx, when developed, appears as an internal *tongue* within the mouth, and the salivary glands, originally having ducts opening external to the mouth, open instead beneath the hypopharynx, within the mouth. Tables D and E are attempts to exhibit these results in concise form.

TABLE D.

TABLE OF COMPARISON OF THE APPENDAGES OF THE HEAD  
SEGMENTS IN VARIOUS GROUPS OF ARTHROPODA.

## A. FOUR AND FIVE-SEGMENTED HEADS.

SEGMENT.	ONYCHOPHORA Embryo and Adult.	CRUSTACEA Nauplius Larva.	ARACHNIDA Embryo and Adult.	DIPLOPODA. PAUROPODA.
1.	(Eyes)	(Eyes)	(Eyes)	(Eyes)
2.	Antennæ	1st Antennæ	(Rostrum)	Antennæ
3.	Jaws	2nd Antennæ	Chelicerae	(Intercalary)
4.	Oral Papillæ	Mandibles	Pedipalps	Mandibles
5.				1st Maxillæ

TABLE E.

TABLE OF COMPARISON OF THE APPENDAGES OF THE HEAD  
SEGMENTS IN VARIOUS GROUPS OF ARTHROPODA.

## B. SIX-SEGMENTED HEADS.

SEGMENT.	TRILOBITES.	CRUSTACEA. Adult.	SYMPHYLA. Adult.	CHILOPODA. Embryo and Adult.	INSECTA. Embryo and Adult.
1.	(Eyes)	(Eyes)	(Eyes)	(Eyes) (pre-antennæ)	(Eyes)
2.	Antennæ	1st Antennæ (Antennules)	Antennæ	Antennæ	Antennæ
3.	1st Maxilli- pedes	2nd Antennæ (Antennæ)	(Intercalary)	(Intercalary)	(Intercalary)
4.	2nd Maxilli- pedes	Mandibles	Mandibles	Mandibles	Mandibles
5.	3rd Maxilli- pedes	1st Maxillæ (Maxillulæ)	1st Maxillæ	1st Maxillæ	1st Maxillæ
6.	4th Maxilli- pedes	2nd Maxillæ (Maxillæ)	2nd Maxillæ	2nd Maxillæ	2nd Maxillæ

Let us now turn our attention to the Insecta.

The whole of this Class, with the exception of the Collembola and Protura, may be placed as definitely *epimorphic* in their ontogeny, i.e., the young larva hatches out with the same number of somites as the adult. One may, for the purposes of this discussion, omit those very highly specialised types which have passed even beyond epimorphosis, in that a reduction of some of the original somites may have taken place either in the adult or in both larva and adult, e.g., in the reduction of the number of definite abdominal segments to less than ten. Also we may leave out of account the problematical interpretation of certain so-called "protopod" larvæ in parasitic Hymenoptera.

In the Protura, there is a definite *anamorphic* type of ontogeny. The young larva hatches out with only nine abdominal segments, and three more are added in the form of small annular somites to form the adult abdomen with twelve segments.

If the Collembola were truly epimorphic, they ought either to hatch out with the full number of somites characteristic of the Insecta, or else show indications, either in their embryology or in the course of larval development, of the reduction which has taken place. There is, however, no sign of this at any stage. The embryonic development proceeds up to the formation of six abdominal segments only; the larva hatches in that stage, and the adult retains exactly that number of segments. I propose to term this type of ontogeny *protomorphic*.

If we compare this with the larval stages of the Pauropoda (Table C), we shall see that the Collembola appear to have stopped short, as far as their postcephalic segmentation is concerned, at the stage indicated by the twelve-legged larva of the Pauropoda. Now about the only fact known concerning the ontogeny of the Symphyla is that they also pass through a twelve-legged larval stage. As the presence of two pairs of maxillæ and definite hypopharynx and maxillulæ have been proved for this group, we can now make an even closer comparison and say that the Collembola possess exactly the segmentation of the twelve-legged larvæ of Symphyla. The only difference lies in the appendages, all of which are retained in the Symphyla, including a pair of unjointed cerci.

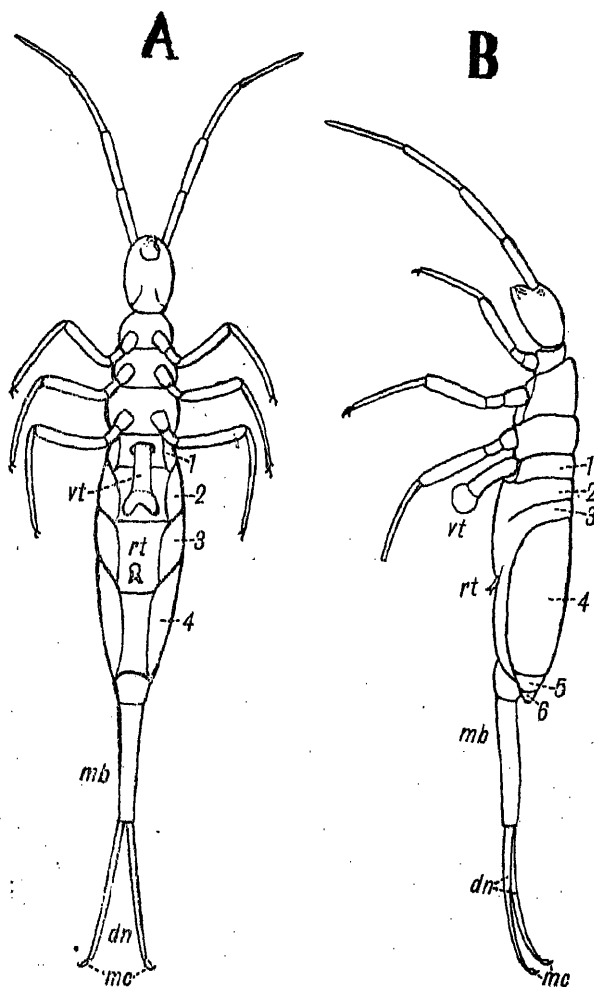


Fig. 14. Diagrammatic view of a Collembolon, family Entomobryidae. A, ventral view, B, lateral view, showing the abdominal segments, numbered 1-6, the catch or retinaculum (*rt*), ventral tube (*vt*), and the parts of the spring or furcula, viz., manubrium (*m*), dens (*d*), and mucro (*mc*).

Further support for this view is obtained when we come to study the development of the appendages in Collembola (fig. 14). In the embryo, all the postcephalic segments show the rudiments of appendages except the last two, viz., the preanal and anal. This is an exact parallel to the condi-

tion of the postcephalic region in the twelve-legged larva of Pauropoda. Before hatching, the appendages of the second abdominal segment (fifth postcephalic) disappear. In the newly hatched larva, the appendages of the first abdominal segment (fourth postcephalic) become fused to form the *ventral tube* (fig. 14, *st*); those of the third abdominal segment (sixth postcephalic) also fuse to form the *catch* or *retinaculum* (fig. 14, *st*), and those of the fourth abdominal segment (seventh postcephalic) remain very large and are only partially fused to form the large *spring* or *furcula*; this organ has a fused basal portion or *manubrium* (fig. 14, *m*), a pair of elongate *dentes* (*d*) and small terminal portions or *mucrones* (*mc*).

Thus, of all the original paired appendages of the postcephalic region in Collembola, only one pair, those of the fifth segment, have been lost.

In the twelve-legged larva of Pauropoda, it is also true that only one pair of original postcephalic appendages disappear; only, in this case, it is the first pair, not the fifth.

In the twelve-legged larva of the Symphyla, none of the appendages of the postcephalic region degenerates except those of the preanal segment, which appear to be partially atrophied. The anal segment bears a pair of short cerci, which are absent in Collembola and Pauropoda.

The result of this survey of the Collembola is most interesting. They are classified as Insecta; but, according to our analysis, *they have just as much right to be classed as Myriopoda as have the Pauropoda*. The only difference is that, while they retain all their original appendages except one pair, only the first three postcephalic appendages remain as functional walking-legs; *the remainder are modified to serve other functions*.

The conclusion appears to be irresistible that, unless the Collembola are not true Insects, then the Insecta, Pauropoda, and Symphyla have all been derived from a common ancestor with segmentation similar to that of Collembola.

Table F presents in tabular form the results of our analysis of the ontogeny of the groups under discussion, together with the Arachnida and Tardigrada.

TABLE F.

ANALYSIS OF THE TYPES OF POSTCEPHALIC SEGMENTATION IN  
VARIOUS GROUPS OF ARTHROPODA.

<p><b>PROTOMORPHISM:</b>—The preservation of an original condition with few body segments, without change from embryo to adult.</p> <p><b>ANAMORPHISM:</b>—The formation of few body segments in the embryo, with addition of further segments during larval life, the full number being reached at a late larval or adult stage.</p> <p><b>EPIMORPHISM:</b>—The formation of the full number of body-segments while still in the embryonic condition.</p>			
GROUP.	PROTOMORPHIC.	ANAMORPHIC	EPIMORPHIC.
TARDIGRADA	All forms (?)	————	————
ONYCHOPHORA	————	————	Peripatoidea
MYRIOPODA	————	Pauropoda Symphyla Diplopoda Chilopoda (part) Schizotarsia	Chilopoda (part)
INSECTA	Collembola	Protura	Thysanura Pterygota
TRILOBITA	————	All forms	————
CRUSTACEA	————	Most forms	Syncearida, etc.
ARACHNIDA	Pycnogonida (?)	Xiphosura	Scorpionida Araneina, etc.

## THE EVOLUTION OF THE WALKING-LEG.

We can scarcely be wrong in deriving the walking-leg in Insects and Myriopods from an originally unsegmented process such as is found in many Annelid worms. The first truly Arthropodan stage may be envisaged as a still simple, unsegmented, short appendage provided with two sets of opposable muscles, extensors and flexors, and ending in one or two claws. This stage is represented in the limbs of Tardigrades. The next stage consists in a slight elongation of the leg, with annulation of a primitive type, as is to be seen in *Peripatus*. With further elongation comes the differentiation of the definitive segments, each having its chitinous exoskeleton somewhat hardened in comparison with the chitin of the joint, and thus for the first time becoming a definite unit in the leg mechanism. The walking-legs of both Insects and Myriopods are of this type, but show a wide range of evolution, both in the number of the segments and in their individual specialisations.

Comparing the walking-leg of the typical Myriopod with that of an Insect we are at once struck with the fact that the



Myriopod leg is of a more primitive type in not having the marked specialisation of femur and tibia which is to be found throughout the adult stages of most Insects. Let us then, first of all, follow out the evolution of the walking-leg in the various groups of Myriopoda.

The simplest type of Myriopod leg is that found in the Symphyla (fig. 15). It is usually stated to consist of five segments. We propose, however, in this paper, to consider that the leg proper starts with the coxa, as it does in the Insecta. The coxa of an insect shows a definite articulation with the sternal and pleural regions of the thorax. A careful examination shows that the segment which has this articulation in the Symphyla is the rather large, stout segment (*cx*) which is fourth from the distal end. Further, this segment is articulated with a kind of slightly chitinated socket, from the pleural portion of which there is developed a long, slender, curved apodeme (fig. 15, *ap*). From the sternal part of this socket are developed the ventral sac (*vs*) or eversible vesicle, and the style (*st*). I propose to call all this region the *subcoxa*. The sternal part is clearly homologous with the *subcoxal plate* in the abdominal segments of *Machilis* (fig. 6, D, *scx*); for this plate also bears the ventral sac and the style in that family, and lies behind the true sternum, which is a weakly chitinated, triangular plate (fig. 6, D, *sn*). In our view, then, the leg proper begins with the coxa, and the number of segments must be counted from that as the basal segment.

A comparison of the four-segmented leg of *Scolopendrella* (fig. 15) with the four-segmented leg of a Collembolan (fig. 14) will here prove useful. In the latter, the four segments are known as the coxa, trochanter, femur, and tibio-tarsus; these names, therefore, may also be used for the four segments of the leg in Symphyla. It is worth noting that the tibio-tarsus in Collembola ends in a well-developed claw and an empodium; the tibio-tarsus of *Scolopendrella* also ends in a claw and an empodium.

Returning to the legs of Myriopoda, we find the next stage, a six-segmented leg, in the Pauropoda and some of the Diplopoda. This condition appears to have arisen by the interpolation of two short segments between the original femur and tibio-tarsus of a four-segmented leg of Symphylian type, as in the Oniscimorphous Diplopoda. In the higher groups of Diplopoda, the distal segment becomes divided into two, giving a seven-segmented leg. In some cases, there ap-

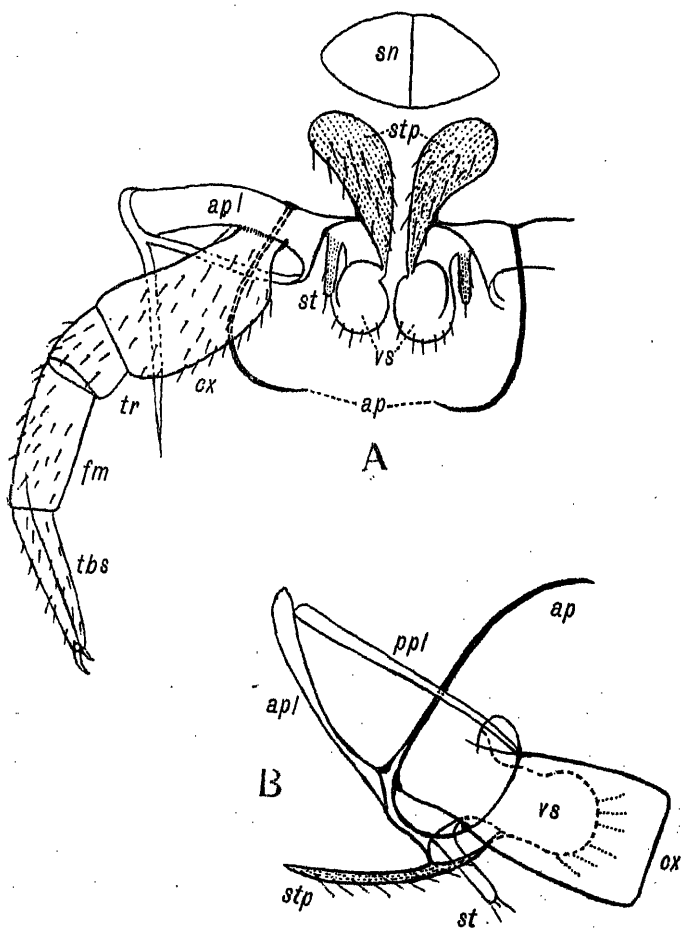


Fig. 15. Sternal region and leg in *Scolopendrella* sp., Australia. Class Progoneata, Order Symphyla, family Scolopendrellidae. A, ventral view, drawn from a cleared and mounted KOH preparation stained in eosin. B, lateral view, drawn from an unmounted KOH preparation stained in eosin and cleared in clove oil, to show correct position of parts. *ap*, apodeme; *apl*, anterior pleural process, *ppl*, posterior pleural process, and *stp*, sternal process of the subcoxa; *cx*, coxa; *fm*, femur; *sn*, sternum; *st*, style; *tbs*, tibiotarsus; *tr*, trochanter; *vs*, exsertile vesicle. In B, all segments of the leg are omitted except the coxa, and the exsertile vesicle is indicated by dotted lines as it lies behind the coxa.

pears to be a further subdivision, more or less complete, of the distal segment, so that the highest type of leg evolved in this group may be said to be eight-segmented. The Diplopoda are also remarkable for the approximation of the two coxæ, which remain large, and in the setting-apart, in the males, of one pair of legs to form the copulatory organs.

Turning next to the Opisthogoneate Myriopods, we have to determine which is the true coxa in the Chilopoda. There are two more or less well defined, small, ring-like segments at the base of the leg, the first of which frequently bears a small style resembling that of the coxa of *Machilis*. This should therefore be the coxa, and the second short segment should be the trochanter. Following this are five well developed segments, so that we may call the typical Chilopodous leg seven-segmented. In some groups, however, the distal segment is either more or less completely subdivided into two, so that the highest development is again an eight-segmented leg.

A very remarkable and high degree of specialisation of the legs is attained by the Schizotarsia, an aberrant offshoot of the Chilopoda. In these the two distal segments of an originally seven-segmented leg become greatly elongated and very slender; each is subdivided into a number of annuli or secondary segments. This condition is usually spoken of simply as "multi-articulate," but the original point of division between the two distal segments proper is easily seen at an elbow near the middle of the annulated portion. The animal walks or runs by means of the first five segments of each leg only, and uses the two distal ones in a most extraordinary manner. It captures its prey by leaping upon it and enclosing it in a veritable basket or cage of legs; while devouring its prey at leisure, it keeps the terminal segments of its legs vibrating at a rapid rate, thus producing a misty effect and rendering itself almost invisible! A further interesting point is that a true "breaking-joint" is formed between trochanter and femur, thus enabling the animal to escape with ease if one of its long legs is either caught in a crevice or seized upon by an enemy.

It will be seen from the above account that the line of evolution of the Myriopod leg, after the Symphylian stage, cannot be homologised segment for segment with the Insect leg.

Turning now to the evolution of the Insect leg, we take up the story again at the Collembola (fig. 14), in which the comparison with the leg of the Symphyla is very close. This leg is four-segmented, and the tibio-tarsus ends in a claw plus an empodium. The subcoxal region is extremely primitive, with very slight chitination. The next stage is to be found in the five-segmented legs of Protura and Thysanura Entotrophica; the additional segment is formed by subdivision of the tibio-tarsus into distinct tibia and tarsus. In the Protura, the specialisation of femur and tibia, which is strongly marked in most adult insects, is not at all marked, so that these primitive insects are closer to the Myriopoda in this character than other insects. The Projapygidæ (fig. 12) are somewhat more specialised in this respect; the Japygidæ (fig. 11) a little in advance of the Projapygidæ; and the Campodeidæ (fig. 10) are slightly in advance of the Japygidæ.

No group of Insects now exists with a six-segmented leg which has not been attained by reduction; the few types in which the tarsus is at present two-segmented can all be proved to be reductions from a type in which the tarsus was originally three-segmented. Within the Thysanura, the distinction between the two groups Entotrophica and Ectotrophica is most marked; all the former have the tarsus simple, while in the latter it is never less than three-segmented. A few forms of Lepismatidæ are known in which the leg is eight-segmented (tarsus four-segmented) but these are obviously secondarily derived from forms having the typical seven-segmented legs of the Ectotrophica.

The Pterygota appear at first sight to centre round two distinct lines, one having the tarsus three-segmented and the other five-segmented. To the former would belong the fossil orders Palæodictyoptera and Megasecoptera, and also a number of recent groups (Dermaptera, Plecoptera, Copeognatha, Hemiptera, etc.). Handlirsch, who regards the Palæodictyoptera as the ancestral type of the Insecta, would also claim that this three-segmented condition of the tarsus is the primitive condition. But we have very clear evidence from the fossil record that the three-segmented condition has been secondarily derived from a five-segmented one in Perlaria and Copeognatha, and there is some evidence that the three-segmented condition in Odonata may also be a reduction. I am therefore inclined to consider the five-segmented condition

of the tarsus as the primitive form for Pterygota, especially as the Plectoptera, both fossil and recent, have five-segmented tarsi.

Here let us pause once more to collect into tabular form our analysis of the evolution of the walking-leg in terrestrial Arthropoda (Table G).

The next stage of our analysis brings us to the question of the relationship of the typical uniramous legs of terrestrial Arthropoda to the primitive biramous types of marine Arthropoda. We have to ask the question: Is there any real evidence of descent of the terrestrial uniramous walking-leg from the marine biramous appendage of Trilobites and Crustacea?

TABLE G.

TABLE SHOWING EVOLUTION OF THE TYPES OF WALKING-LEG  
IN ANNELIDA AND ARTHROPODA.

(x Present.)

TYPE.	ANNEL- IDA.	TARDI- GRADA.	ONYCHO- PHORA.	MYRIOPODA.	INSECTA.
Unsegmented Process	x				
Simple Leg with Claws		x			
Simple Leg with Claws and primitive annulations			x		
Four-segmented Leg with single tibiotarsus				x Symphyla	x Collembola
Five-segmented Leg with separate tibia and tarsus					x Protura x Thysanura Ectotrophica
Six-segmented Leg				x Pauropoda x Diplopoda	
Seven-segmented Leg				x Diplopoda x Chilopoda	x Thysanura Ectotrophica x Pterygota (some)
Seven-segmented Leg with secondary annulations				x Schizotarsia	
Eight-segmented Leg				x Diplopoda x Chilopoda	x Thysanura Ectotrophica (some)
Nine-segmented Leg					x Pterygota (most)

This brings us at once to the much-debated question of the coxal styles of Machilidæ (fig. 6, C, *st*). According to those who support the descent of Insects from Crustacea, these styles are either true exopodites or true epipodites. If the original basal segment of the leg in *Machilis* is the sub-coxa (fig. 6, D, *scx*), then the style *may be* a true exopodite, as it is borne on the second segment (coxa). If, however, the coxa is the true basal segment, then the style cannot be an exopodite, though it *might be* an epipodite. In either case, the presence of similar styles on most of the abdominal segments of Machilidæ, and, indeed, of most abdominal segments in the Thysanura, has been claimed as additional evidence of the descent of these insects from Crustacea. Let us examine the position more closely.

It seems clear that the abdominal styles in Machilidæ are not the homologues of the coxal styles of the second and third thoracic segments; for the abdominal styles are borne on the subcoxa (fig. 6, D, *scx*) and must therefore be the homologues of the styles found in *Scolopendrella* (fig. 15, *st*). These styles are situated just externally to the *exsertile vesicles* (*vs*) in both cases.

The double homology of coxal style and ventral sac is quite inexplicable except on the ground that the Symphyla and Machilidæ were derived from a common ancestor.

Further, we have to note the occurrence in Chilopoda and Schizotarsia of small coxal styles on most of the legs. These are clearly homologous with the coxal styles of Machilidæ. But these groups have not developed the sub-coxal styles and sacs. Hence we may safely conclude that both types of style are not remnants of original epipodites, or exopodites, but merely a special development which took place at some stage in the evolution of the common ancestor of Myriopods and Insects, and were carried over into certain ancient types of both Classes.

As there is not a particle of other evidence throughout the Myriopoda and Insecta for the occurrence of either an exopodite or an epipodite, I think we are entitled to conclude that there is really no evidence whatever for the evolution of the walking-leg of the terrestrial Arthropod from the biramous swimming limb of the marine Arthropod.

We see, then, that the course of our investigation has again forced us into the position of maintaining some kind of relationship between the Symphyla and the Apterygota,

although we are no longer thereby put into the position of the original supporters of this theory, in so far as it involved them in acceptance of the Symphyla as the nearest approach to the ancestral group of the whole of the Insecta.

Our conclusions may be stated as follows:—

- (1) No evidence exists for the origin of the walking-leg of Myriopoda and Insecta from a biramous type of limb.
- (2) Coxal styles occur in Chilopoda, Schizotarsia, and the Machilidæ.
- (3) Subcoxal styles and eversible ventral sacs occur in Symphyla and Thysanura. Subcoxal styles also occur in Protura.

#### REPRODUCTIVE SYSTEM; THE PROBLEM OF THE POSITION OF THE GONOPORE.

Having thus arrived at a point where it is idle to shut our eyes to the fact that the evidence so far disclosed points to a much closer hereditary connection between Myriopoda and Insecta than between Crustacea and Insecta, we come now right up against the old crux, which may be stated as follows:—

All the older types of Myriopoda are progoneate. The Chilopoda and Schizotarsia are, it is true, opisthogoneate, but nobody proposes to derive the Insecta from either of them. All the Insecta are opisthogoneate. How can one bridge the gap between the progoneate Myriopods and the opisthogoneate Insecta?

It has long appeared to me that this problem is almost insoluble, if we are not to go back nearly to an Annelid ancestor with paired segmental gonads and gonoducts. However, a new solution now presents itself as the outcome of the present analysis, and I shall try to explain it clearly herewith.

In the following discussion, all segments will be reckoned from the head backwards as *postcephalic*, without regard to the presence of the thorax in the Insecta, since it is admitted that the thoracic region of an insect is composed of the first three original postcephalic segments of a more primitive type.

Above reckoning, the Collembola possess nine postcephalic segments. If my theory that they are more

primitive than other Myriopoda and Insecta, as regards their segmentation, is correct, then they never had more than nine postcephalic segments.

The gonopore in Collembola opens on the eighth postcephalic segment. In the Thysanura and most Pterygota the male duct opens on the twelfth postcephalic segment, the female on the eleventh. In the Plectoptera, however, the female ducts, which are paired, open on the tenth postcephalic segment. In the Protura the genital ducts open between the last two segments, i.e., the fourteenth and fifteenth postcephalic. In the Chilopoda, they open on the last segment. All these variations are included in the one term *opisthogoneate*.

In Diplopoda the genital ducts open on the third postcephalic segment; there are also, in the male, accessory copulatory structures either on the last segment, or on the seventh or eighth. The Pauropoda also have the genital ducts opening on the third postcephalic segment; the Symphyla on the fourth. Both these conditions are classed as *progoneate*.

Now nobody denies that Plectoptera and the rest of the Pterygota had a common ancestor because the female ducts in the former open one segment in front of their position in other Pterygota. Nor would they deny the unity of the Class Insecta on the ground that the position of the gonopore, though *opisthogoneate*, was not the same in Collembola, or in Protura, as it is in the Thysanura or the Pterygota.

Thus the issue as between the term "*progoneate*" and the term "*opisthogoneate*" is seen to be essentially one of degree. Granted that the divergence between the position of the gonopore in Symphyla and in Thysanura is too great to be "jumped," we may nevertheless ask *what amount of divergence would be permitted* for the present objection to the postulation of a common ancestor to be overcome? The reply must be, unless we are to be entirely illogical, that a similar amount of divergence must be permitted as is already accepted within one of the two divergent groups, say, the *opisthogoneate*. In this group the most forward position for the gonopore is actually to be found in the Collembola, strange as this may seem; for they have the genital opening on the eighth postcephalic somite!

Now the most backward position of the gonopore in the *Progoneata* lies on the fourth postcephalic segment. Hence



the gap to be bridged between existing Progoneate and Opisthogoneate forms is to be measured only by the gap between the fourth and eighth postcephalic segments, provided we agree that these two conditions occurred in ancestral forms that were closer together than any existing at the present day within the two opposed groups.

Let us now ask: How could forms having such divergent positions for the genital openings as the fourth and eighth postcephalic segments arise from a common ancestor? To answer this satisfactorily, we must search for evidences of a primitive segmental condition of the gonads within the types under review. We have not to search very far, for the Thysanura include numerous examples, particularly in the females, which appear to retain, on the whole, a more primitive arrangement of the gonads than the males. Probably the most primitive of all existing arrangements is that found in the females of Japygidæ, where there are seven pairs of ovaries segmentally arranged in the first to seventh abdominal segments, i.e., *in the fourth to tenth postcephalic somites*. The oviducts of each set of seven ovaries unite to form a single longitudinal oviduct on each side, and these two oviducts open together into the genital opening or gonopore at the posterior end of the eighth abdominal segment. There is, therefore, an extension of at least one whole segment as between the position of the most posterior pair of ovaries and the gonopore.

Now we must conceive that, originally, each pair of gonads discharged its products through the paired ducts of its own somite, and that these opened either in the sternum itself or at the bases of the legs attached thereto. Thus it would appear that there has been a loss of the last pair of gonads in the Japygidæ, and we ought to demand, therefore, a minimum of eight pairs of gonads in the ancestral type for Thysanura and Pterygota. That this is correct is shown by an examination of the ovaries in the Pterygota, where, although the segmental arrangement has been lost, the maximum number of ovaries on each side appears to have been eight.

The next point to bear in mind is that, on the basis of our new theory, the evolution of existing forms with either fourteen or fifteen postcephalic somites must have taken place originally, as in Protura, by anamorphosis, i.e., by addition at the posterior end, either just in front of the preanal segment, or just in front of the anal segment. As

both types of addition are known to occur in existing Myriopoda, either may be allowed in the evolution of groups which have now become epimorphic in their ontogeny.

It is clear, then, that the number of eight pairs of gonads, arrived at above as the ancestral number for Thysanura and Pterygota, is not necessarily the ancestral number for the protomorphic ancestors of these groups, but has almost certainly been arrived at by the addition of gonads developed in the extra segments added by anamorphosis during evolution. As, on the argument already developed above, the gap to be bridged between primitive progoneate types and primitive opisthogoneate types is only the gap between the fourth and eighth postcephalic somites, it seems fair to assume that a *protomorphic ancestor with only five functional paired gonads* is required, and the extra three pairs must have been added during anamorphosis.

Let us now see how the evolutionary lines work out, with the aid of diagrams (figs. 16, 17, 18).

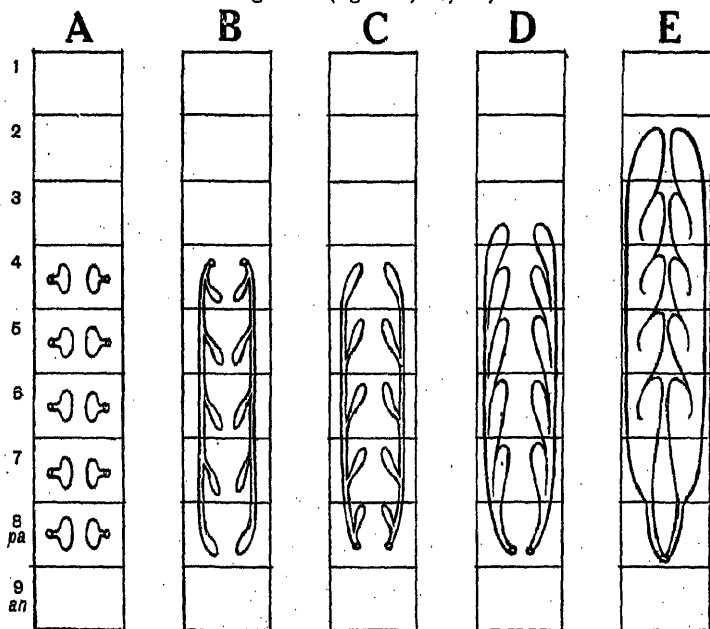


Fig. 16. Evolution of the Reproductive System. Diagrammatic. A, ancestral condition with five pairs of segmental gonads and separate gonopores. B, evolution of the primitive progoneate type. C, evolution of the primitive opisthogoneate type. D, Proto-collembolan stage (male). E, Collembola (Poduridae, male). The numbers indicate postcephalic somites; an, anal, and pa, preanal somites.

(1) *The original condition in the protomorphic ancestor of both progoneate and opisthogoneate forms:*—Even if we grant that the original terrestrial ancestor of Myriopoda and Insecta had a number of postcephalic somites *not less than the Collembola*, it is not required that functional gonads need have been present on any somites except the fourth to eighth postcephalic inclusive. Fig. 16, A shows this condition. Each gonad discharged its products through its own segmental duct, as indicated above.

(2) *Evolution of the primitive progoneate type:*—This would be accomplished by the fusion of all the ducts along each side into a single gonoduct opening forwards into the original pore of the fourth postcephalic somite. The remaining pairs of gonopores must have become vestigial and later on disappeared. Probably also the most anterior pair of gonads (those of the fourth postcephalic somite) also became vestigial and later on disappeared. Fig. 16, B shows this condition.

(3) *Evolution of the primitive opisthogoneate type:*—This would be accomplished by a fusion of all the ducts along each side, similar to that in (2), but opening backwards into the original pores of the eighth postcephalic somite, instead of forwards into the fourth. As in (2), all the remaining pairs of gonopores must have become vestigial and later on disappeared. Fig. 16, C shows this condition.

(4) *Stages in the Evolution of the progoneate type:*—It would appear probable that, during anamorphic evolution of the progoneate type, the original pair of gonads in the fourth postcephalic somite has degraded and disappeared; at the same time, probably at least three extra pairs of gonads have been developed posteriorly, in the ninth to the eleventh postcephalic somites, during anamorphosis, either during a single interpolation of three segments, or during two stages of addition, of two segments followed by one more (as in the larval development of Pauropoda). Fig. 17, B shows this intermediate or Proto-pauropod stage. From it, there can easily be developed the adult condition found in the Pauropoda (fig. 17, C) in which the ducts have been extended forward one segment (probably by ectodermal additions) so as to open into the third postcephalic somite, while the gonads of the fifth and sixth segments appear to have been lost, and the remaining pairs have combined into two groups, each extending through several segments, and thus partially obscuring the original segmental arrangement.

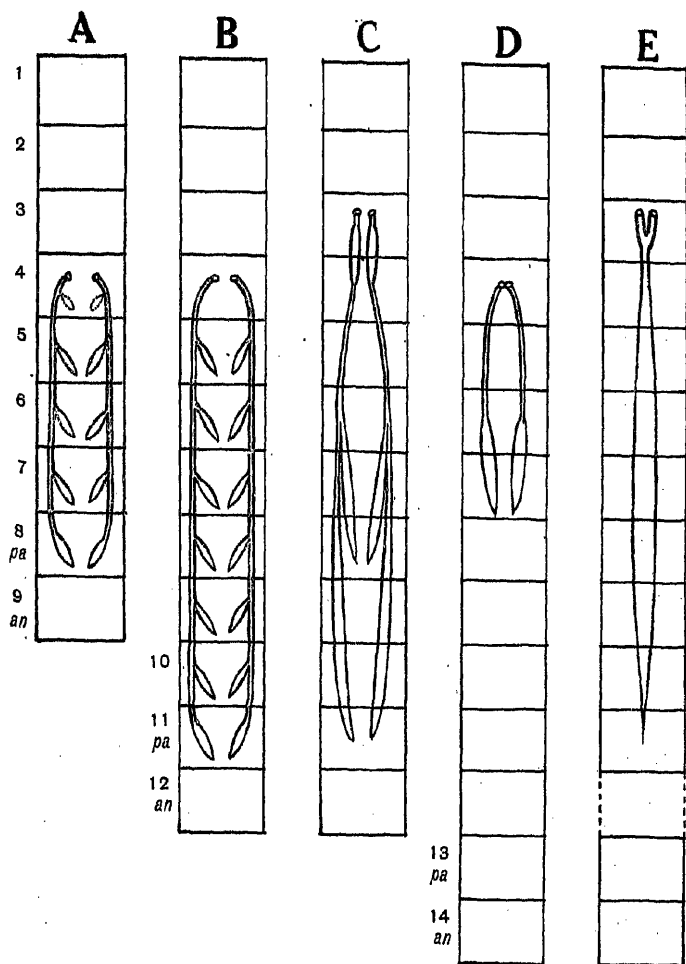


Fig. 17. Further Evolution of the Progoneate Type of Reproductive System. Diagrammatic. A, ancestral progoneate (as in fig. 16, B). B, intermediate or Proto-pauropod stage, leading to C. C, Pauropoda. D, Symphyla. E, Diplopoda. The numbers indicate postcephalic somites; an, anal, and pa, preanal somite. All diagrams represent female organs.

In the Symphyla (fig. 17, D), the original position of the gonopores is retained, but there is a very great reduction in the gonads; apparently only those of the sixth and seventh postcephalic somites have been retained, and these are fused on each side, so as to obliterate the original segmental arrangement.

The Diplopoda (fig. 17, E), like the Pauropoda, have specialised in the forward movement of the gonopores, but appear to have retained a larger number of the original pairs of gonads; these, however, have all become fused together to form one great, elongated gonadial chamber. The paired ducts have also fused, except towards the gonopores, where they remain separate.

How close these hypothetical stages in the evolution of the reproductive systems of the various types of Progonaeta actually come to the truth can only be discovered by very careful examination of the embryonic and larval development of the gonads in existing types. This has, apparently, not yet been attempted. If, however, my new theory at all approximates to the actual course of evolution of the ancestors of Myriopoda and Insecta, such a study as this should yield many points of evidence in its favour, or, alternatively, offer evidence demanding some reconstruction of its details.

(5) *Stages in the Evolution of Opisthogoneate types*:—Starting from the ancestral protomorphic opisthogoneate type already envisaged (fig. 16, C), we have to follow out four distinct lines of evolution as follows:—

(a) *The Collembola* (fig. 16, D, E):—Here the intermediate stage may be conceived of as an enlargement of the five gonads on each side to a stage in which their separate ducts become obliterated (fig. 16, D). This may be termed the Proto-collembolan stage. The condition of the male gonads in Poduridæ is a little further advanced (fig. 16, E), the gonads on each side forming a huge convoluted mass projecting as far forwards as the mesothorax, but still showing definitely its origin from five originally distinct gonads. In the females fusion proceeds further, and apparently all signs of the original segmental arrangement are lost.

It is important that the embryonic formation of the testes in some primitive Podurid should be worked out completely, so as to determine which five postcephalic somites actually produce the paired gonads.

We must note that, as there has been no anamorphosis in the Collembola, the evolution of the gonads must have been comparatively simple, and has only involved the original elements present in the hypothetical ancestor of both progonaeta and opisthogoneate types.

(b) *The Protura* (fig. 18, A, B):—For the evolution of this type, we require two anamorphic stages. In the first, the original five pairs of gonads were retained, and the position of the gonopores was probably pushed backwards to between the anal and preanal segments. By interpolation of three more segments just anterior to these, without development of extra gonads within them, we reach what we may term the *Proto-proturan Stage* (fig. 18, A), originally an adult condition, but now represented by the larval form with

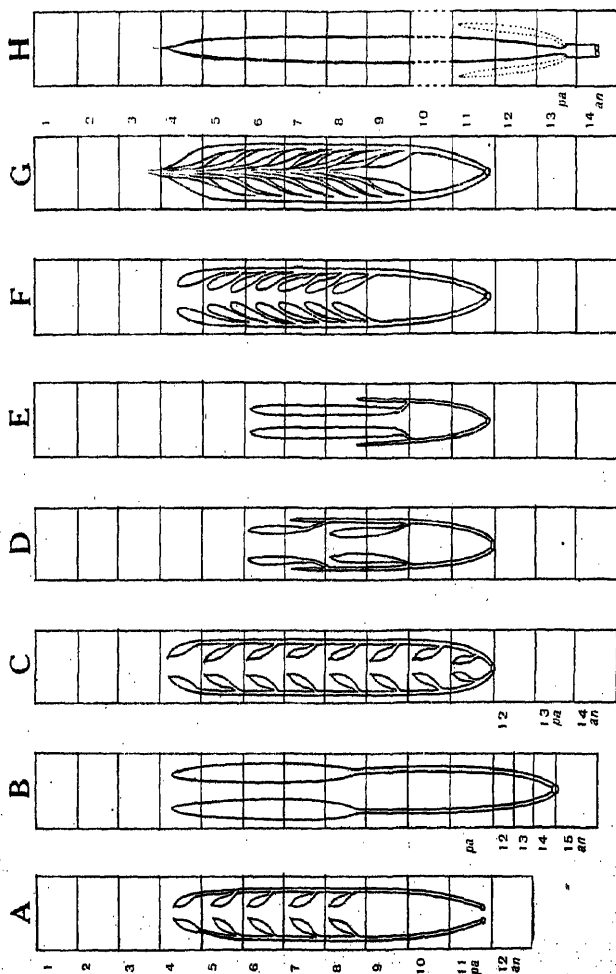


Fig. 18. Further Evolution of Opisthogonate Types. Diagrammatic. A-B, Proturan line. C-G, Thysanuran-Pterygotan line. H, Chilopoda. A, Proto-proturan stage, intermediate between ancestral type (fig. 16, C) and B, Protura. C, Proto-thysanuran stage, leading to Japygiidae (fig. 11) by loss of last pair of gonads. D, Pterygotidae (fig. 12). E, Camptodeidae. F, Machilidae. G, typical primitive Pterygot type. H, Chilopoda; this stage and any later ones indicate the extreme extension of the additional posterior portion of ectodermal origin. Numbers indicate postcephalic somites; an, anal, and pa, preanal somite. All diagrams represent female organs.

nine abdominal segments. Either before or after this stage was reached, the paired gonads must have become fused into two elongate organs of the type now existing in the Protura. The present Proturan stage (fig. 18, B) has been reached simply by a second anamorphic development, resulting in the addition of three ring-segments just in front of the anal segment.

(c) *The Thysanura and Pterygota* (fig. 18, C-G):—The evidence favours a common ancestor for these two groups, which we may term the Proto-thysanuran stage (fig. 17, C). It must have had eight pairs of gonads, and must also have been developed anamorphically from the ancestral protomorphic opisthogoneate type (fig. 16, C) by the addition, either at a single stage or at two, of three additional somites in front of the preanal.\* From this type, the Japygidæ (fig. 11) evolved simply by loss of the most posterior pair of gonads: the segmental condition of the other seven remains complete to the present day in the females, and the only other specialisation is the union of the two original gonopores on the preanal segment. The Projapygidæ (*Anajapyx*, fig. 18, D) show a further stage of reduction, the gonads being reduced to two pairs only; each of these two, however, is probably composed of two or more of the original segmental gonads. The end development of this line is to be found in the Campodeidæ (fig. 18, E), where all the remaining gonads on each side are fused into a single elongate organ.

The Machilidæ and Lepismatidæ apparently constitute another line of development, in which (fig. 18, F) the original seven pairs of gonads retained in the Japygidæ lose their segmental arrangement and become more crowded together (Machilidæ). In the Lepismatidæ, either there is a secondary reduction to five pairs only, or, just possibly, these five pairs may actually represent the original five pairs of the ancestral protomorphic type, carried over unchanged.

It is interesting to note that, on this new theory, the two lines of evolution of the reproductive organs in the *Thysanura Entotrophica* and *Thysanura Ectotrophica* are seen to be distinct, but quite closely related.

Turning next to the Pterygota (fig. 18, G), the line of evolution follows closely that of the *Thysanura Ectotrophica*,

\*Possibly the undeveloped, annular nature of the ninth abdominal segment in Japygidæ is evidence that it was the last segment to be added anamorphically in the ancestor of Thysanura.

but apparently the whole eight original pairs of gonads are retained, though their segmental condition is lost. The condition found in the females of Plectoptera, in which the two oviducts open separately on the tenth postcephalic somite instead of on the eleventh, is quite possibly not primitive, but a secondary development correlated with the necessity, in these delicate and short-lived insects, for freeing large masses of eggs as quickly as possible.

(d) *The Chilopoda and Schizotarsia* (fig. 18, H):—What little is known about the gonads in this group indicates that they have pursued their own line of evolution quite independently of that of the Insecta. It is not possible to indicate the stages in its development very closely, but an examination of the female reproductive organs in the more primitive groups ought to afford some evidence of it. In the best-known form, *Scolopendra*, the whole of the original gonads are fused together to form an elongated single organ (fig. 18, H). This organ lies in the middle line, below the alimentary canal and above the central nervous system. Its form appears to be correlated with the great elongation and narrowing of the animal's body. The gonopores open together on the last segment; probably the extension backwards from the original position on the preanal segment has been accomplished by the formation of a secondary ectodermal portion of the ducts, posterior to the entry of the two accessory glands (fig. 18, H, dotted portions); or, alternatively, the true anal segment may be vestigial, as in most Insecta.

Before leaving this subject of the reproductive system, it will be as well to say a few words about the Crustacea. In this Class in general, the gonopores may open in any position from the first to the nineteenth postcephalic somite. The posterior position is, however, very unusual, and is only to be found in certain Branchiopoda in which a very large addition of somites has taken place. Such types, of course, do not enter into the discussion of the origin of Insecta in any case. *All the types of Crustacea which can possibly come into the discussion are classifiable as progoneate types, in contrast with the Insecta.* Moreover, none of them shows the primitive segmental arrangement of gonads required of the ancestor of the Insecta. Take, for instance, the Syn-carida. In this group the ovaries form an elongate mass running from the posterior part of the thorax into the abdomen; the oviducts open on the inner faces of the coxopo-



dites of the sixth pair of thoracic limbs. The testes are long slender tubes with their vasa deferentia opening on the sternal surface of the last thoracic somite. Thus in the Syncarida the gonopores of the female belong to the sixth postcephalic somite, those of the male to the eighth!

In order, then, for the Syncarida to be the ancestral group to the Thysanura, it is necessary to postulate a lost type of Syncarid in which the gonopores of the two sexes were placed much farther back; to wit, in the female, no less than five segments back, and in the male, four! There is not the slightest evidence that such a type ever existed; whereas there is plenty of evidence that both progoneate and opisthogoneate types of terrestrial Arthropoda arose from a single stem.

One is not surprised that no advocate for the Crustacean origin of Insects has ever yet been bold enough to mention the gonads!

As for the Trilobites, nothing whatever is known about their reproductive system, so it is idle to speculate. Probably their gonads remained segmental, with many paired gonopores. They were certainly quite primitive enough to have been *possible* ancestors of almost any group of higher Arthropoda; but we have already seen that Handlirsch's method of filling in the intermediate stages is not acceptable, and there does not appear to be any other suggestion worth considering.

The Onychophora are already almost as highly specialised opisthogoneate types as the Chilopoda. Therefore no Peripatoid type can possibly have been the ancestor of such a form as *Japyx*, which has retained segmental gonads. Unless some evidence can be brought forward giving a direct evolutionary connection between Onychophora and primitive Myriopodan types, it would appear to be useless to bring them into the argument at all.

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We may reasonably conclude this stage of our argument by presenting a somewhat diagrammatic "phylogenetic tree" embodying the combined results of our analysis of the evolution of the body-segmentation, of the walking-leg, and of the reproductive system. It would be almost impossible to indicate, in a single diagram, the evolution of a series of groups based on the study of these three characters, if it were not that they reinforce one another in a very complete manner. The result is to be seen in fig. 19.

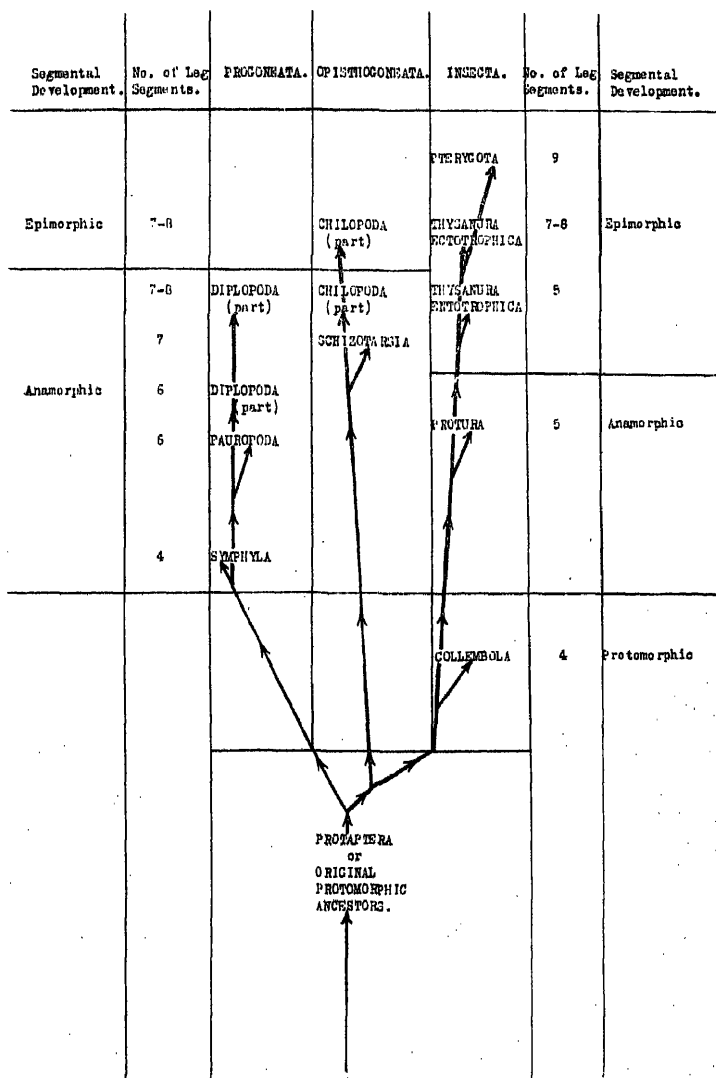


Fig. 19. Phylogeny of the Insecta according to the New Theory. The thick, arrowed lines indicate the courses of evolution. The type of segmental development and form of walking-leg are indicated in vertical columns on either side of the phylogenetic tree.

We have now set out the main lines of our new theory, and must proceed to test it along the same lines that I have indicated for existing theories. That is to say, we must consider the various systems of internal organs, the embryology and the geological record of the groups under consideration, and see how far the evolutionary record in each case either supports or conflicts with the theory.

#### THE RESPIRATORY SYSTEM.

This is considered first because it appears to be, next to the segmentation and appendages, the system which has already given rise to most discussion.

Generally speaking, marine Arthropods breathe by means of external gills, which may, or may not, be secondarily covered for protection, while terrestrial Arthropods breathe by means of an internal system of tracheæ or air-tubes, developed from invaginations of the ectoderm. Nobody would to-day, as far as I know, postulate a single great monophyletic group Branchiata for all the gill-bearing forms. On the other hand, Versluys (1914-1922) has resurrected the old group Tracheata for all the tracheate forms, and claims that it is a monophyletic group. Let us examine the position afresh.

How far is Versluys justified in his contention?

I have indicated, in my criticism of Versluys' Theory, that it would appear that he has made out a good case for the terrestrial Arachnida being actually more primitive than the marine forms. At first sight, the geological record would appear to deny this. But we have to remember that fossil records of land animals living before the Lower Devonian are extremely scarce, so that it is fair to assume that we know relatively little of what terrestrial life was like during the Cambrian and pre-Cambrian periods. The discovery of an abundant fossil fauna of Acarina in the Lower Devonian peat-bogs, associated with small Crustacea and also with true Collembola, should make us pause before asserting that the geological record is against Versluys. For the Acarina are undoubtedly very highly specialised; they stand above the epimorphic groups of terrestrial Arachnida and are remarkable for having undergone considerable reduction both in the larval and adult conditions. The loss of abdominal segmentation, of demarcation between cephalothorax and abdomen, and specialisation of mouth-parts, are all specialised adult characters, while the secondary reduction of the larval

legs to three pairs (proved by the embryonic development of *four* pairs in at least one primitive form) is a specialisation unparalleled within the Class.

But when Versluys wishes to assert that the Arachnid tracheal system arose monophyletically with that of other terrestrial Arthropods, I disagree with him entirely. This assertion involves the evolution of all types of Arthropod tracheation from that of Onychophora, which is, to me, unthinkable.

Let us, first of all, clear the ground, by removing from the argument all obviously secondarily derived structures, whether of tracheæ or gills. In this category come—

- (a) all tracheal gills developed in various groups of Insect larvæ, and
- (b) all so-called "tracheal systems" developed in terrestrial groups of Crustacea, such as the Oniscoid Isopoda.

As regards (a), the fact that all these gills contain tracheæ is definite proof of their secondary nature, and is incidentally proof that all groups that possess such organs are *secondarily* aquatic and not primarily so. As regards (b), it is clear that, morphologically, these structures are in the nature of pseudotracheæ and not tracheæ, and the fact that they are borne on the exopodites of the pleopods, which are obviously marine developments, is as strong a proof of their secondary nature as is the possession of tracheæ in the gills of aquatic insect larvæ.

Thus we dispose of two points, viz.:—

- (1) The occurrence of aquatic insect larvæ with tracheal gills does not prove that the insects were aquatic in origin, but reinforces the belief that they were terrestrial.
- (2) The supposed "tracheal system" of Oniscoidea is not only *no proof* of the origin of Insecta from Crustacea, but is definitely against it; for it is obvious that no Insect tracheal system has been developed from such a system as is found in the Oniscoidea.

Now there are clearly three main systems of respiration within the Arthropoda, viz.:—

- (1) through the cuticle,
- (2) by means of gills, and
- (3) by means of tracheæ.

Primitive forms are known, both marine and terrestrial, which breathe directly through the cuticle. The primitive gill of a marine Arthropod is a specialised outgrowth of the cuticle, either from part of a somite, or part of an appendage. It is therefore of the nature of an evagination designed to increase the amount of permeable surface presented to the oxygen-carrying medium, i.e., salt-water. In the case of an appendage, further advantage is gained by the ability to wave it to and fro. The primitive trachea, as seen in the Onychophora, for example, is an invagination of the cuticle, designed to increase the amount of permeable surface and also to bring the air into closer contact with the various internal organs in need of oxygen. One need scarcely be surprised that, in the case of an animal with such a soft cuticle as *Peripatus*, no definite segmental arrangement of the tracheal system was evolved.

It should be clear, then, that there is no more necessity to demand a monophyletic origin of all tracheate Arthropoda from an original tracheate form than there is to demand a monophyletic origin of all gill-bearing marine forms from a single gill-bearing marine type. On the other hand, there is plenty of evidence available to show that the original terrestrial types of Arthropod possessed no tracheæ at all, but simply breathed through their cuticle.

The Collembola, which, on my new theory, are the most primitive of all Insects, and, in some ways, notably in their protomorphism, more primitive than any existing Myriopoda, are entirely without tracheæ except in the case of the highly specialised family Sminthuridæ, in which a single pair of tracheæ occurs in the head region. I submit that, if Collembola were descended from tracheate forms, any type which now possessed a tracheal system would not have been the most highly specialised type, but one of the more primitive forms; nor would the tracheæ have been in the head, but in some segment which would have clearly indicated a reduction from the original postcephalic segmental system, as exhibited, for instance, in the more primitive Thysanura or Pterygota.

The Pauropoda have no tracheal system either. Here again we are dealing with a group which, on my new theory, is extremely archaic, being as old, almost, on the progoneate side, as the Collembola are on the opisthogoneate side.

The tracheal system of Diplopoda, with its tufts of fine tubules passing inwards from each spiracle, does not appear

to be monophyletic with that of the Insecta or of the Chilopoda.

The tracheal system of the Chilopoda may have originated from the same stem as that of the Thysanura, or it may have arisen independently. Its highest expression, in the Schizotarsia, is of a type without parallel in any of the higher Insecta, where the tendency, indeed, is strongly towards reduction of the tracheal system.

The Protura possess a tracheal system with thoracic spiracles only. This is quite in line with my theory if we consider that the most primitive Insecta had no tracheæ, the intermediate anamorphic types only a partially developed (thoracic) system, and the higher types, Thysanura and Pterygota, a much more complete system.

It is still quite permissible to argue that the tracheal system of the Campodeidæ is a reduction from a more complete system present in the ancestral Thysanuran. Indeed, on my new theory, this is more probable than that the Campodeidæ show a primitive system comparable with that of Protura. For the series Japygidæ-Projapygidæ-Campodeidæ is, on my new theory of the evolution of the reproductive organs, a complete reduction series, and the presence of two thoracic and one abdominal pairs of spiracles in *Anajapyx* points in exactly the same direction.

On the other hand, I would regard the tracheal system of the Symphyla as extremely primitive, and as one of the very first attempts to develop a tracheal system of the Diplopod type, with numerous fine tubules not anastomosing within the body. In this, as in many other characters, I consider the Symphyla to be much more primitive than the Campodeidæ. It is evident that there has been a considerable amount of convergence between the two groups, giving a superficial appearance of much closer relationship than really exists.

When we turn to the marine series, we find small, primitive types of Crustacea without any special gill-formation, but breathing only through the cuticle. In the higher types, especially in the Malacostraca, the gill-series is of high complexity. Particularly we must take account of the gills of Syncarida, as these have been considered as possible ancestors of the Insecta. In this group, the gills are provided on the epipodites of the thoracic legs, and show a progressive reduction from the primitive Anaspididæ, through the Koo-

nungidæ to the Bathynellidæ. There can be little doubt that the last-named family is the most debased and specialised of the Syncarida, both on account of reduction of its appendages and also in its remarkable habits of living. So, then, if we are to derive the Insecta from Syncarida, we must picture them as having passed from marine to estuarine waters, thence to fresh-water rivers, thence to cave-waters and wells as Bathynellid-like forms; thence they must have emerged as cave-dwellers in the form of Machilidæ, with the vestiges of their original gills still in the form of coxal styles! Obviously a most fascinating theory, but scarcely a convincing one! The only position to which I am willing to relegate it is one in which the Syncarida must be considered as the ancestors of the whole Myriopod-Insectan complex, and I am afraid that this would take the ancestor too far back, both geologically and as regards its segmentation, to keep it within practical considerations. If any worker in these fields considers that there is a good case for a Syncarid ancestry of Insects, then such a theory must take a definitely opposed stand to my new theory of the protomorphic origin of Insects and Myriopods, and must regard forms like Collembola and Pauropoda as having evolved from ancestors having the exact segmentation of Syncarids. This, I venture to suggest, would be extremely difficult to maintain.

Further, any supporter of the Syncarid or, more generally, the Crustacean origin of Insects must admit my argument in favour of the Insects having evolved from types without a tracheal system. But this, again, throws them back on a consideration of Collembola and Pauropoda as very primitive types, and places them somewhat on the horns of a dilemma.

#### THE ALIMENTARY SYSTEM.

A very simple evolutionary line can be established for the digestive system of Onychophora, Myriopoda, and Insecta. In *Peripatus*, the endodermal region, or mid-gut, occupies most of the length of the digestive tube, while short ectodermal portions, covered with an extremely fine chitinous cuticle, form the fore-gut anteriorly and the hind-gut posteriorly. This type of digestive tube persists in the Myriopoda, with a tendency towards slight lengthening of the fore- and hind-guts at the expense of the mid-gut. In the Insects the mid-gut region becomes further shortened, and the lengthened regions of fore- and hind-gut tend towards differentiation of parts, which, however, vary greatly accord-

ing to the group of insects under consideration, and the type of food consumed. In primitive Insects, there is never any development of an ectodermal stomach or gizzard, of the type found in Crustacea.

In the Crustacea, from the earliest types onwards, there is a marked shortening of the mid-gut region and a high stage of development of the fore-gut. The latter becomes differentiated into the œsophagus and stomach, or gizzard, the latter being developed *within the head*; and there is a marked bend in the course of the œsophagus upwards and forwards into the head before reaching the stomach.

If, then, the Insecta are derived from Crustacea, the whole of this important development of the fore-gut must have become degraded and then must have entirely disappeared! Not a trace of it is left, in any primitive Insect.

Further, in Crustacea there is developed, from the anterior portion of the mid-gut in the embryo, a voluminous set of hepatic cæca, or a liver. This type of organ is also quite unknown in the Insecta. The corresponding portion of the embryonic mid-gut in Insects has been proved only to develop up to a certain point, and the two glandular pockets formed by it are only transitory structures and soon disappear. One would certainly expect to find a greater development of the liver, if Insects are derived from any group of higher Crustacea, though the condition found is not incompatible with a derivation from some early type of proto-Crustacean, such as the Nauplioid ancestor already postulated.

The evidence would point strongly to a close relationship of Myriopoda and Insecta, with a possible, but by no means certain, derivation from Onychophoroid forms; any relationship indicated with Crustacea is seen to be, by comparison, a much more distant one.

#### THE EXCRETORY SYSTEM.

In the Crustacea the most important excretory organs are the paired antennary and maxillary glands. The former open at the base of the second antennæ. In Branchiopoda, they develop before the maxillary glands, and function during larval life; they then atrophy, and their function is taken on by the maxillary glands. They become the "green glands" of the Decapoda. The maxillary glands open at the base of the first maxillæ; in Decapoda, they sometimes precede



the antennary glands in functioning, thus reversing the order found in the Branchiopoda. In this latter group they become the "shell-glands."

In the Syncarida, a single pair of excretory glands is well developed behind the mandibles. These would appear to be homologous with the maxillary glands of other Crustacea, but their ducts have not yet been traced with certainty.

*No Crustacean is known with any trace of Malpighian tubules.*

The essential excretory organs of terrestrial Arthropoda (exclusive of the Onychophora, which still retain the nephridia of Annelids) are known as *Malpighian tubules*. They occur in terrestrial Arachnida, in Myriopoda, both Progoneata and Opisthogoneata, and in Insecta. Those of Arachnida are shown by embryology to be special developments of the endoderm, and form diverticula of the hinder end of the mid-gut. Those of Myriopoda and Insecta agree in being of ectodermal origin, and form diverticula of the anterior portion of the hind-gut. Thus it is only in the Myriopoda and Insecta, amongst all the groups of Arthropoda, that true *ectodermal* Malpighian tubules are developed.

There could scarcely be a more striking testimony to the essentially close relationship between Myriopoda and Insecta than this.

If it be objected that certain Insecta, e.g., *Japyx*, do not possess Malpighian tubules, and that, therefore, they must be regarded as organs specially developed within the Class, I would reply that I have myself dissected *Heterojapyx* and have found there a set of six short diverticula at the anterior end of the hind-gut. These are evidently Malpighian tubules in a reduced form. Probably a transverse sectioning of the same region in *Japyx* would reveal their presence.

Silvestri (1905) has demonstrated the presence of six short Malpighian tubules in the family Projapygidae (*Anajapyx*). The Protura also have six very short ones, in the form of small papillæ. The Campodeidae have sixteen very short tubules, but the Thysanura Ectotrophica have them well developed though variable in number. The Collembola alone do not possess them and apparently have never possessed them at all; these forms carry on their excretion, apparently, entirely through the cuticle.

In the Myriopoda, the Pauropoda agree with the Collembola in possessing no Malpighian tubules. The Symphyla have two, well-developed; the Chilopoda and Schizotarsia two to four; the Diplopoda are apparently variable, but with not more than four.

It would thus appear that Malpighian tubules probably developed in the common ancestor of *Myriopoda* and *Insecta* at a stage later than the differentiation of the two most primitive groups, Collembola and Pauropoda.

This does not in itself definitely disprove an *ultimate* origin of both groups from some very primitive form of Crustacea, such as the hypothetical Nauplioid ancestor. But it appears to me to be much opposed to the theory of descent from any of the higher Crustacea, more particularly as not only the antennary glands of the latter Class, but also the appendages connected with them, are nowhere to be found in the *Insecta*. Small maxillary glands are known to exist in Collembola and Protura, but they do not exercise an excretory function.

#### THE CIRCULATORY SYSTEM.

In all Arthropoda the heart is an elongated dorsal vessel, supported by segmentally arranged alary muscles and having paired segmental ostia with valves to allow only ingress and not egress of the blood. This dorsal organ lies in the thorax and abdomen, and opens by means of the dorsal aorta into the head. In *Insecta* and most *Myriopoda* there are no closed circulatory vessels beyond the heart and dorsal aorta. Some of the higher *Myriopoda*, however, e.g., *Chilopoda* and *Schizotarsia*, have a well-developed arterial formation. In the *Insecta* and the lower groups of *Myriopoda*, the blood for the most part circulates in an open hæmocœle or blood-cavity, and only its forward dorsal movement is controlled by the heart and aorta. This type of circulatory system must be regarded as quite primitive, and closely resembling that of the *Onychophora*; probably the evolution of the tracheal system robbed the blood of a large share of one of its chief functions, that of oxygenation of the tissues, and thus prevented further development of the closed circulatory system.

Arterial development is found to a greater or less degree in most types of Crustacea, and it is clear that types like the *Branchiopoda* and *Syncarida*, not to mention the higher *Malacostraca*, are far in advance of the *Insecta* in their cir-

culatory systems. In *Bathynella* the short heart is reduced to a position in the fourth thoracic somite. Other Syncarida also have the heart shortened, and this can even be seen to some extent in the more primitive Leptostraca. On this ground alone it would appear impossible to derive the Insecta or Myriopoda from any of the higher Crustacea.

The evidence points to the early forms of Myriopoda and Insecta having had a very primitive form of circulatory system, and their descendants having preserved this primitive type with little modification beyond increase or decrease of the number of segmental divisions of the heart. Collembola have a six-chambered heart, the divisions being in the second to seventh postcephalic somites. It seems probable that the anal and preanal somites originally did not develop such chambers and that the dorsal aorta originally belonged to the first postcephalic somite. Thus the type of heart found in Collembola may be the exact ancestral type. With the evolution of anamorphic types, the number of chambers would be increased. The probable maximum development in the Insecta is that found in *Periplaneta*, where the heart is said to have no less than thirteen chambers. Most of the Pterygota, however, have less than this, the usual number being seven to ten, while there are instances of reduction to three, or even to a single chamber.

#### THE CENTRAL NERVOUS SYSTEM.

There is little to gain from a study of the central nervous system in the groups under discussion. It is evident that this system shows a wider divergence in passing from the more primitive to the higher types of Crustacea than it does in the Myriopoda and the Lower Insecta. In the lower Crustacea the two longitudinal nerve-cords are wider apart, the connectives better developed, and the component ganglia of the suboesophageal complex more distinct than in any Insect type. By the time that the Malacostraca are reached, however, the evolution appears to have passed beyond that of the lower Insecta; the longitudinal cords are well fused together, the connectives obliterated, and the suboesophageal ganglion has begun to incorporate within itself the more anterior of the thoracic ganglia. How far this process has gone in Syncarida it does not appear possible to determine. Of *Parabathynella*, Calman (1917) states that "the central nervous system is remarkably bulky in comparison with the other organs. The ventral nerve-cord shows some de-

"gree of longitudinal concentration (not very fully described), and the ganglia are indistinctly defined from the "connectives."

The higher Insects, of course, develop an extreme concentration of the central nervous system and a more complex brain than can be found anywhere within the Crustacea.

### THE SENSE ORGANS.

We need only consider here the *eyes* and the *antennæ*.

(1) *The Eyes*:—The Arthropod eye began as a pit-like depression in the ectoderm, from which there was evolved a type of simple eye similar to that found in many Myriopoda and also in the larvæ of some Insects. This simple type, called an *ocellus*, has the hypoderm layer composed still of a single layer of cells, but those that border the pit become differentiated into vitreous-body cells and retinal cells, the latter secreting rods. The lens is formed simply by thickening of the cuticle over the pit.\*

From this simple type we can derive all the types of compound eyes found in Arthropoda. I have already considered the problem of the evolution of this organ in Arthropoda, in dealing with Versluys' Theory (p. 26) and can only repeat my conclusion that compound eyes have been formed at least four times within the Phylum, independently of one another, viz., in the Myriopoda (*Scutigera*), in the Insecta, in the Crustacea (primitively a stalked type), and in the Arachnida.

(2) *The Antennæ*:—A comparison of the antennæ of the Onychophora, Myriopoda, and Insecta appears to indicate very clearly the line of evolution of these organs. Probably originally a pair of unsegmented processes, they first of all became annulated. In that stage, with only slight elongation, they are to be seen in *Peripatus* to-day. Right at the very base of the Myriopod-Insectan stem they would appear to have evolved into a higher type, in which the annuli had become definite segments. Only the basal segment, or scape, receives the insertion of the antennary muscles. The primitive number of segments would appear to have been only three, viz., scape, pedicel, and distale. The earliest known fossil Insecta, viz., the Lower Devonian Collembola, have the

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\*Except in the Onychophora, where it is a separate body below the cuticle.

distale indistinctly divided into two subsegments, thus foreshadowing the normal Collembolan development of four segments.

The four-segmented condition must also have been the original one for the ancestors of Progoneata; for we find in the Pauropoda that the antennæ have four simple segments surmounted by two *which both spring from the fourth*, thus furnishing the only example in the whole of the Myriopod-Insectan series of a truly biramous antenna! In Diplopoda two segments are added *in series*, making six in line as the basic type for this group—more being added in the higher forms.

The condition of the antennæ in Pauropoda has not yet, as far as I am aware, been advanced by any author as evidence of descent from Crustacea; howbeit, we may be sure that, if the Pauropoda had been Insecta, it would have been so advanced. Let us examine such a claim to see how much it is worth.

The antennules or first antennæ of Syncarida consist normally of three well-developed basal segments followed by two rami; the internal ramus is well developed, and is in the form of a flagellum with many annular segments; the external ramus is shorter and composed of few segments. In the Bathynellidæ the internal ramus is shortened to five segments, while the external ramus is a mere stump. The second antennæ are somewhat like the first, but the external ramus is never well developed; it may be formed of a single well-developed segment, or be reduced to a stump or scale.

In the Pauropoda, the whole of the antenna is held in a position *transverse to the body axis*. The Syncarida have the first two segments pointed forward and the remainder transverse.

To develop the Pauropod type of antenna from that of the Syncarida one would have to assume that the ancestral form was even more degraded than *Bathynella*. Both internal and external rami would be reduced to a single segment; but, incidentally, an additional basal segment must have become developed, for the rami of the Pauropod antenna arise from the fourth, not the third segment.

Admitting that this *might* have happened, we have then to face the fact that *in no other character do the Pauropoda approach the Syncarida*. The anamorphic development of the Pauropoda and the fact that, even in the adult form,

their segmentation does not agree with that of the Syncarida, must surely put them clean out of court as a possible connecting link with Crustacea.

In the Protura the antennæ appear to have been lost. This is noteworthy as indicating that these organs were probably very short in the hypothetical proto-Proturan ancestor. Many Insect larvæ have the antennæ so short that little more is needed for complete suppression. In many of the higher Insecta and Myriopoda, however, a long antenna or "feeler" is developed, with very numerous flagellar segments, all originally evidently annulations of the single elongated distale or its primary subdivisions.

There would appear, then, to be no evidence whatever for the derivation of the Insect antenna from the first antenna of Crustacea, and a great deal of evidence to show that it was never anything but a uniramous appendage similar to a primitive leg.

(3) *The Second Antennæ*:—The only types of Crustacea in which these are lost are certain Branchiopoda and Oniscoid Isopoda. Nobody, however, proposes to derive the Insecta from such types. The entire absence of these organs, which are of great importance in the Crustacea, is a grave difficulty which must be overcome before any theory of the origin of Insecta from Crustacea can be acceptable.

#### EMBRYOLOGY.

None of the theories so far put forward concerning the origin of the Class Insecta appear to have taken into account the evidence from Embryology. It is clear, however, that an acceptable theory must not do violence to the established facts in the embryology of the groups concerned which bear definitely on the course of evolution. For that reason, I shall content myself with a study of two outstanding points in the embryology of Insects and related groups, and shall try to discover how they bear on theories of their origin:—

(1) *The Evolution of the Cœlome*:—The Arthropoda in general are remarkable for the great reduction of the secondary body-cavity or *cœlome*, which makes way for an entirely different type of cavity called the *hæmocœle*, developed by the shrinking apart of ectoderm from endoderm, the space between being filled with blood. This reduction must be regarded as fundamental for Arthropoda; for it is seen to be already in quite an advanced stage in the Onychophora. In

this group the original cavities of the mesodermal somites divide into dorsal and latero-ventral portions. From the walls of the dorsal portions are formed the lateral walls of the heart and the pericardial septum, while, below these, in certain somites only, another portion persists and gives rise to the gonads. The latero-ventral portions become the excretory organs or nephridia.

Now, both in Myriopoda and in Insecta, the portion of the cœlome forming the nephridia degenerates; but the dorsal portion behaves very much as in *Peripatus*. The choking-up of the primitive cœlome is also to a large extent brought about by the formation of the voluminous *fat-body* from the cells of its inner wall.

The *fat-body* reaches an enormous development in many of the larvæ of Holometabolous Insects. *It is a development entirely confined to Myriopoda and Insecta*. It may, then, rightly be claimed as strong evidence of the essential unity of origin of the two groups, as set out in my new theory.

When we turn to the Crustacea, we find a complete absence of the development of a fat-body, together with an even more marked degradation of the original cœlome. Correlated with this is the higher development of the hæmocœle with its definite arterial and venous systems.

It would not be easy to establish the possibility of the evolution of the condition of the cœlome and hæmocœle as found in the Insecta and Myriopoda from even a primitive type of Crustacean. Evolution from any higher type, such as the Syncarida, becomes even more difficult to imagine, and I think we can safely claim that the evidence afforded by the embryology of the cœlome is opposed to it.

(2) *The formation of the embryonic envelopes (amnion and serosa)*:—In the embryology of all Insecta so far examined, from the primitive *Machilis* and *Lepisma* right up to the highest Pterygota, the embryonic area becomes invaginated into the yolk. The opening of this invagination is called the *amniotic pore*. In *Machilis* it remains large; in *Lepisma* it is small but remains open; in the higher Insecta it becomes completely closed. The inner limb of the fold forms the inner embryonic membrane or *amnion*; the outer forms the outer embryonic membrane or *serosa*. As the invagination is not completely closed in such a type as *Machilis*, the amnion cells come to cover the posterior half of the egg as well as the immersed embryo, while the serosa cells cover the anterior half of the egg.

The formation of these embryonic envelopes is almost unique within the Arthropoda. But in the Myriopoda (*Scolopendra*) there is found a condition closely analogous to that found in *Machilis*. The embryonic area becomes infolded into the yolk; but this infolding is only temporary, and straightens out again when most of the yolk has been absorbed. Now, in *Machilis*, when the embryo becomes exerted after the original invagination, the anteriorly situated serosa gives way to the posteriorly situated amnion and decreases in size to form the so-called *dorsal organ*. In *Scolopendra* there is an analogous but less marked formation of a corresponding dorsal organ, in the neck region of the embryo; this may rightly be regarded as the first rudiment of a true serosa.

Nothing resembling the above processes is to be found in the Crustacea. We must therefore conclude that, on the evidence, the Myriopoda are most closely related to the ancestral type of Insecta. If the Insecta have been derived from any type of Crustacea, then it would appear inevitable, on the evidence of the embryology, that the Myriopoda were also derived with them by a common ancestor.

#### THE GEOLOGICAL RECORD.

We must preface this section with the remark, which is, of course, a truism, that we are here dealing with an incomplete record. But, although admittedly incomplete, our knowledge of fossil Arthropoda, and more particularly of fossil Insects, has progressed very greatly during the past twenty years. Table H is an attempt to present this knowledge in a form that can be easily assimilated.

In order to aid our understanding of the Table, let us picture to ourselves the primitive Palæozoic world which was the seat of our evolutionary drama. Admittedly long before the dawn of the Cambrian Period the seas were filled with living things; marine animals, at any rate, had reached a high degree of complexity in the Lower Cambrian. Terrestrial forms came later. Except for the highly probable occurrence of Onychophora (*Aysheaia*), there are no terrestrial Arthropod groups represented in the record until the Scorpions appear in the late Ordovician. Closely following these appear, in the Lower Devonian, Diplopoda belonging to extinct groups, Collembola and Acarina very similar to existing forms, and perhaps also Thysanura.



TABLE H.  
GEOLOGICAL RECORD.  
(x Present.)

GROUP.	CAMBRIAN.	ORDOVICIAN	SILURIAN.	DEVONIAN.	CARBONIFEROUS.	PERMIAN.
ANNELIDA	x .....					
ONYCHOPHORA	x? ( <i>Ayshecia</i> ) .....					
TRILOBITA	x .....					x
CRUSTACEA	x .....			{ x Leptost. ....	x Syncarida .....	
MEROSTOMATA	x .....					
TERRESTRIAL ARACHNIDA		x .....		{ x Acarina .....		
DIPLOPODA				x .....		
CHILOPODA					x .....	
COLLEMBOLA				x .....		
THYSANURA				x? ( <i>Rhynognatha</i> ) .....		
PTERYGOTA						x .....

Winged Insects, however, which of all insect forms are much the most likely to be preserved as fossils, do not appear until the Upper Carboniferous. Even if this record is not complete, and the Pterygote insects really existed in the Middle or Lower Carboniferous, to me it seems quite impossible to conceive that they existed in the Lower Devonian, when there were no trees on the earth at all, and only a few of the first exceeding primitive vascular plants had begun to appear on the land. One can conceive of forms like *Peripatus* living under rocks in a primitive world where fungi, algæ, and such-like simple plant-forms were the only vegetative covering; one can admit that Scorpions may have lurked in the crevices, Thysanura may have run or jumped about there, and Collembola and Acarina may have worked away amongst the débris as they do to-day. But it seems hardly possible to admit the Pterygota to a place in the Lower Devonian landscape!

Let us admit, then, that the discovery of Collembola in the Lower Devonian peat-bogs has dealt a hard blow at that part of Handlirsch's Theory which would make the vari-

ous groups of Apterygota degraded side-branches from an older Pterygote stem. This part of Handlirsch's Theory must fail because it does violence to the known geological record. We must, of course, recognise, in justice to the talented author himself, that Handlirsch did not know of these Devonian fossils, which were only worked out nearly twenty years after he first published his theory. Further, the new facts appear to me to be fatal to the whole of Handlirsch's Theory, since, to be at all logical, it demands that the winged insects must have preceded the wingless forms.

Almost any other theory would be tenable on the geological record. The Myriopoda go back as far as the beginnings of the Insecta; the Onychophora probably well beyond them. The marine Crustacea are so ancient that even comparatively highly organised forms like the Syncarida were well represented in the Carboniferous, and quite probably in the Devonian also. Admittedly there is not much of a margin here for derivation of Insects from Syncarida or Leptostraca; but we must not press this too hard, because we still have a very imperfect fossil record of these groups.

Thus the sole definite conclusion that we appear entitled to draw from the geological record is that the Pterygota were the latest and most highly organised of all the groups of Arthropoda, and that Apterygote forms most certainly preceded them.

#### SUMMARY OF THE CHARACTERS OF THE HYPOTHETICAL PROTOMORPHIC ANCESTOR.

(1) *External Morphology*:—Body composed of at most fifteen somites plus telson. Of these, five belonged to the head and ten to the abdomen, but the first abdominal somite became added to the head before the Symphyla and the first true Insecta branched off.

Head segments fused into a capsule. Third segment (intercalary) already degraded and without appendages. Only simple eyes present. A single pair of short antennæ, probably with only three segments (scape, pedicel, and distale). Mandibles with at most only two segments. Maxillæ formed from simple walking-legs with gnathobases developed. Superlinguæ and hypopharynx well developed, indicating an even more primitive ancestral stage, in which the head was composed of only four segments and the mouth was closed posteriorly by these organs, and not by any segmental appendages.

Abdomen, or postcephalon, with each segment carrying a pair of simple walking-legs, except the last,\* in which these appendages were directed backwards as cerci. Each leg with only four segments, viz., coxa, trochanter, femur, and tibio-tarsus. The cerci were probably one-segmented processes, as in Symphyla and Japygidæ.

Respiration was carried out through the integument, which was composed of very soft chitin.

The reproductive organs consisted of probably only five pairs of segmental gonads, each opening by a duct at the base of its corresponding appendage; these were on the fourth to eighth postcephalic somites.

The alimentary canal consisted of a simple, straight tube, with short fore- and hind-gut regions and a considerably longer mid-gut, without diverticula. Small pockets, probably originally two only, at the anterior end of the hind-gut, served for lodgment of uric acid crystals and formed the rudiments of the future Malpighian tubules or excretory organs.

Heart probably only with six chambers (in second to seventh postcephalic somites), each with paired ostia and valves. A dorsal aorta present, leading into the head. No other closed vessels. Pericardial cavity and alary muscles present.

A large hæmocœle and well-developed fat-body present.

Central nervous system with supracœsophageal ganglion composed of three pairs of ganglia, subcœsophageal ganglion composed of the two (or alternatively three) pairs of ganglia supplying the mandibles and maxillæ, and nine pairs of postcephalic ganglia, united by paired longitudinal connectives and transverse commissures.

Embryo with formation of primitive somites to full number present in the adult, but third cephalic somite already degrading and not forming appendage-rudiments. Larva hatched in a form closely resembling adult, which is reached by few ecdyses and with little change beyond increase in size and maturation of gonads.

*Probable geological horizon.*—Upper Silurian.

*Probable ecology.*—Terrestrial, dwellers in moist places, feeding on primitive plant-life.

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\*Or, alternatively, the cerci belonged to the *preanal* segment and the last segment bore no appendages. This point could be definitely determined by reference to the embryology of the Symphyla.

SUMMARY OF THE MAIN LINES OF EVOLUTION FROM  
THE HYPOTHETICAL PROTOMORPHIC ANCESTOR.

(1) *The First Dichotomy*:—The first dichotomy was that into Progoneate and Opisthogoneate forms, by union of gonoducts on each side to open either into the most anterior genital somite (*progoneate*, fourth postcephalic somite) or the most posterior (*opisthogoneate*, eighth postcephalic segment). Intermediate forms all died out. The dichotomy was probably complete by the beginning of the Devonian period. The Collembola are a remnant of the original opisthogoneate stock, but further specialised by the adaptation of the hexapod mode of progression, aided by specialisation of the appendages of the fourth to seventh postcephalic segments to form a complex jumping or springing apparatus (ventral tube, catch, and spring). The corresponding progoneate type has been lost.

(2) *Evolution of the Progoneata*:—Increase of size was attained by the addition of further postcephalic somites anamorphically. The oldest types still extant are the Symphyla and the Pauropoda, which probably evolved in the Middle or Upper Devonian. Probably as a side specialisation from a Pauropoid ancestor the whole of the Diplopoda arose. In these two groups there is a tendency for the abdominal tergites to fuse together in pairs.

(3) *Evolution of the Opisthogoneata*:—Increase of size was also at first correlated in this group with the anamorphic addition of new postcephalic somites. Development, however, was more rapid than in the Progoneate types, tending to eliminate all the early anamorphic types and to replace them by epimorphic forms. There was no early tendency towards fusion of tergites; but a definite dichotomy, already begun or foreshadowed by the Collembola, into *Myriopod types* and *hexapod types*, became gradually intensified and gave rise to the two distinct lines of Opisthogoneata and Insecta. The Opisthogoneata remained anamorphic up to a time when the Chilopoda were fairly well developed; but the higher types of this group became epimorphic. The basic anamorphic type had a six-segmented leg; this gave rise to higher forms with seven to eight-segmented legs, and from the former of these arose the Schizotarsia with "multi-articulate" tarsi. Compound eyes, which were never fully evolved in the Progoneata, were just achieved at the very top of the Opisthogoneata line (*Scutigera*).

(4) *Evolution of the Insecta*:—The hexapod tendency set in even before anamorphosis, and produced the Collembola in the Lower Devonian. The advantages of the hexapod mode of progression made this line evolve more rapidly than either of the others, and so the anamorphic stages were passed through more rapidly. Only a single small anamorphic group of primitive Insecta is left, viz., the Protura, distinguished by the loss of their antennæ. Leaving the Collembola and Protura as lowly side-branches, the main stem passed upwards to a level somewhat higher than that of the Symphyla on the Progoneate side, possessing five-segmented legs, but already fully epimorphic.\* These were the Thysanura Entotrophica. Their evolutionary line is probably represented by the progression Japygidæ-Projapygidæ-Campodeidæ. They must have existed somewhere in the Devonian. At a slightly higher level, they produced a more vigorous type with three-segmented tarsi, exserted mouth-parts, and a more complete tracheal system. These were the Thysanura Ectotrophica. They divided into two main types, the dorso-ventrally flattened running types (Lepismatidæ) and the laterally flattened jumping types (Machilidæ); the latter developed compound eyes. Apparently about the same time the Lepismatoid types again ran ahead of the Machiloid, developing compound eyes and a five-segmented tarsus, and from such an ancestral form arose the whole of the Pterygota.

This Summary should be read in conjunction with fig. 19. The following indicates the Classification which should be adopted, on the basis of the new theory:—

I.	II.	III.
Class	Class	Class
PROGONEATA.	OPISTHOGONEATA.	INSECTA.
Sub-classes.	Sub-classes.	Sub-classes.
SYMPHYLA.	CHILOPODA.	COLLEMBOLA.
PAUROPODA.	SCHIZOTARSIA.	PROTURA.
DIPLOPODA.		THYSANURA.
		PTERYGOTA.

Note:—The name "*Protentomon*" has already been used for the hypothetical ancestor of the Class Insecta, based on more than one theory, so I hesitate to use it again in this address. Perhaps the best name that I could suggest for

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\*See note at bottom of p. 64.

the common protomorphic ancestors of all the Myriopoda and Insecta, as here worked out, would be PROTAPTERA. Such a group would have the status of a Class. The term PROTOCOLLEMBOLA is a little too specialised, to my mind, and too cumbersome also.

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## TASMANIAN CYCADOPHYTA.

By

H. H. SCOTT,

Curator of Queen Victoria Museum, Launceston, Tasmania.

Plates I.-III.

(Read 12th May, 1930.)

## CYCADACEÆ.

Genus *Cycadites*, R. Brown.(Syn., *Mantellia*, Brongniart.)Species *Dowlingi*, sp. nov.

These fossils came to us from the Launceston Tertiary Basin formations at Harland's Rise, Evandale. I regard them as being intercalates derived from the Mesozoic Strata, but the evidence is not absolutely conclusive. All have suffered exceedingly rough usage from natural forces, and are completely pseudomorphed to iron oxide. The latter fact is a depressing one, as it removes all chance of microscopical details being available for determinative purposes. The material at hand is not restricted to a few stems, and other fragments of the apical outgrowths, but the really good specimens are in the minority, and no single specimen is complete enough to serve the desideratum of description, or as a holotype for taxonomic purposes.

In the hope that some histological details had escaped the mutations of time and circumstance an enormous amount of microscopical work was done on selected fragments, and a set of the clays, sandstones, and ferric concretions was passed in optical review. This work, although abortive as to the main object, supplied much data respecting the effect of ferric infiltration into the organic bodies, and the range of external concretion. The personal standard thus acquired proved of inestimable value during the course of the work, and helped me over many of the difficulties incidental to the highly pseudomorphed condition of the fossils. The macroscopic outlines of all woody structures are well preserved, but the finer microscopical details are only now and again glimpsed, and could not be photographically reproduced.

These are Museum specimens for which I desire the scientific status essential for exhibition purposes, and

failing aid from palæobotanists, I am placing them on record for the object named, and without any desire to poach upon the preserves of other scientific workers.

#### TAXONOMIC.

Dr. M. C. Stopes, in the British Museum Catalogue of Mesozoic Plants, page 297, calls attention to the real value of the numerical sequence of the woody rings in the separation of *Bennettites* from *Cycadites* (using, however, the original name of Buckland, viz., *Cycadeoides*, a synonym of *Mantellia*, of Brongniart), and this exceedingly valuable key serves me in good stead, as all our stems have more than two zones. Newell Arber quotes (Cat. Fos. Plants, Brit. Mus., Gloss. Flora, page 210) Zeiller as using the genus *Cycadites* for leaves from Gondwanaland, which brings the genus nearer home, and accordingly is here used for our fossils. The specific name I have linked with that of Mrs. Herbert Dowling, as a small compliment for her many gifts of Tertiary fossils to the Museum, including the specimens here dealt with. As I noted above, the chief object of this paper is to record the find, and as no leaves can be associated with the stems, all the evidence that the fruits and foliage might supply are missing. It must not, however, be forgotten that an isolated cycadaceous leaf from Lord's Hill, Hobart, was recorded by Dr. A. B. Walkom of recent years (Proc. Roy. Soc., Tas., 1924, page 87). All things considered, and open to emendation, the classification adopted seems the best that is possible in the circumstances.

#### DESCRIPTIVE.

After passing a large amount of the material in review, it would appear that the range of useful determinative data is contained within six specimens, which are accordingly selected as cotypes.

##### COTYPE No. 1.

This is part of an elliptical stem, incomplete at both ends; the following are its dimensions:—

Lower elliptical end=186 mm. long  $\times$  75 mm. wide.

Upper elliptical end=160 mm. long  $\times$  73 mm. wide.

Total vertical height=115 mm.

The stem has two dissimilar faces, and suggests that it formed one of a group, since the outer face carried a well-massed group of leaves, that were just continued around the edges of the stem, but did not obtain upon the inner face. Figure 1 will illustrate the leaf scars bounded by the much

altered ramenta, and give a fair outline of the specimen as a whole. The reverse side is, centrally, vertically scarred and filled in with ramental lines. A personal inspection of this specimen reveals some minute details, together with several bud-scars, but no central parenchyma, or woody zones, have survived as in other specimens.

#### COTYPE No. 2.

This is selected to show a fractured transverse section of the stem, and although the nature of the material does not permit of grinding or smoothing, a clean fracture is moderately satisfactory. The items to be noted are the concentric woody layers, the central mass of germinative parenchyma, the incurving leaf-pits, and their altered ramenta.

#### COTYPE No. 3.

Here the central parenchyma is seen in face section, surrounded by the four normal woody layers. It is pitted, in places, as though by the impress of the protoxylem. The specimen is instructive in end view, which is not, however, photographically reproduced.

#### COTYPE No. 4.

This is an apical growth, the stem scar being still in evidence (at the truncated end), by which it was attached to the main stem. It should, therefore, be called a "cone," and is most likely immature. The various woody layers are well shown in the actual specimen. The rounded tubercles may have direct relationship to the attachment of the scales.

#### COTYPE No. 5.

This is either a bud, or very young detached stem. It supplies a developmental note in the item of the outer (fourth in adult specimens) woody zone, which is seen to be double, thus bringing up the xylem zones to six in number. In a few older specimens some slight evidence of this can be detected, but obviously it is only a growth character.

#### COTYPE No. 6.

This is another young specimen which shows some likeness to the figure given by Curruthers, and reproduced by Dr. Stopes, at page 81 of *Cretaceous Flora*, Vol. II., Brit. Mus. Cat. Mesozoic Plants. The item to be noted is the penetration of the basal ends of the leaves to the woody zone. We have many such specimens showing stages of this imagination. Here we miss the silica impregnated specimen, for which iron is but a poor substitute. Most of the speci-

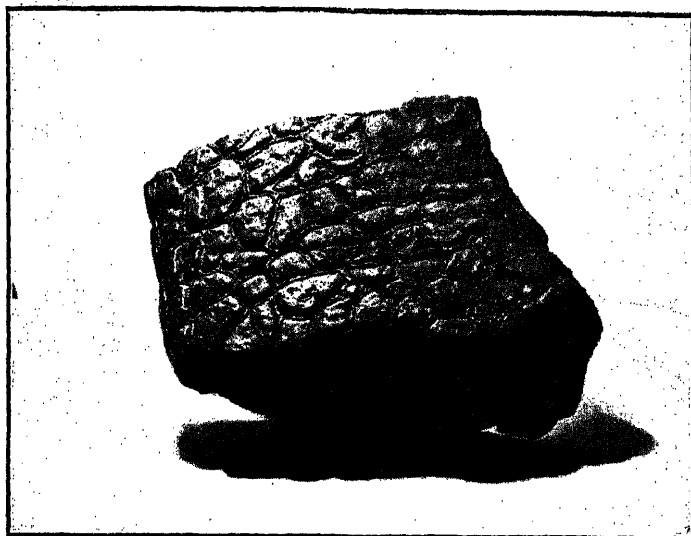


Fig. 1. Matured stem, showing leaf-scars.



Fig. 2. Transverse section, showing woody layers.  
*Cycadites dowlingi*, sp. nov.



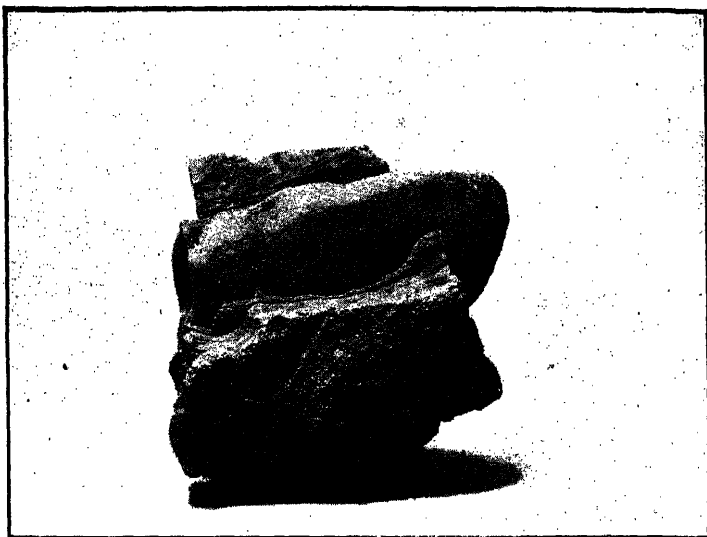


Fig. 3. Fractured vertical section.



Fig. 4. Cone in vertical section.  
*Cycadites dowlingi*, sp. nov.





Fig. 5. Bud in transverse section.



Fig. 6. Smaller bud in transverse section.  
*Cycadites dowlingi*, sp. nov.





mens have been crushed, rolled, and distorted, prior to ferric infiltration, but better ones may come along from time to time. If a specific character is needed, the consistently four-fold nature of the vascular axis, and the dual state of the outer layer, during early growth, should be set against the taxonomic item. As already stated these few notes are purely tentative, the outcome of a Curator's exhibition needs.

#### NAMES OF AUTHORS WHOSE WORKS WERE CONSULTED.

Arber, Newell.  
Buckland, W.  
Balfour, J. Hutton.  
Curruthers, W.  
Decaisne and Le Maout.  
Ethridge and Jack.  
Fiestmantel, O.  
Johnston, R. M.  
Kerner, Anton von Marilaun.  
Lesquereux, L.  
Stopes, M. C.  
Scott, D. H.  
Seward, A. C.  
Sternberg, C. G. von.  
Walkom, A. B.

For the actual collecting of a large number of specimens I am indebted to my son and his wife, Mr. and Mrs. E. O. G. Scott, they having devoted their leisure time to the necessary field work.

#### DESCRIPTION OF THE PLATES.

##### PLATE I.

- Fig. 1.—Matured stem—fragmental—showing leaf-scars.  
Fig. 2.—A fractured transverse section, showing the woody layers—the outer being always wider than the total mass of the inner three.

##### PLATE II.

- Fig. 3.—A fractured vertical section.  
Fig. 4.—A cone in vertical section, the truncated end being basic.

##### PLATE III.

- Fig. 5.—A bud, in transverse section, that yields a growth note.  
Fig. 6.—A still smaller bud, in transverse section, showing leaf stems penetrating to the woody layers.

ON THE SPOROPHORE OF THE NATIVE BREAD  
(*POLYPORUS MYLITTA*).

By

H. STUART-DOVE.

(Communicated by L. Rodway, C.M.G.)

Plate IV.

(Read 12th May, 1930.)

Early in the present month (March, 1930), two specimens of the subterranean fungus called "Native Bread" were received from a settler on the N.W. Coast of Tasmania. They were of an irregular rounded shape, dark-brown on the exterior, but white where the thin rind had been rubbed off. Each weighed about 1½ lb. It was the 3rd of the month when they came to hand. They were placed in an open box in my museum-room, and on 9th inst. one of them exhibited two white knobs, close together, on the upper surface. They much resembled the button-stage of the ordinary mushroom. Each measured slightly over one inch across the top, by  $\frac{3}{4}$  inch in height. By the morning of 12th inst., they had grown to 1½ inches high, the upper surface having changed from white to pale yellow; the underside of the pileus had become wrinkled, but was still closed.

On 14th March the enclosing membrane (velum) had ruptured, and the beautiful yellow tint which had suffused the upper surface of the pileus had become broken by the spreading of the cap; a slight ridge (annulus) stood out about 1-16th inch round the stem at 1 inch from the base, where the velum had ruptured. On the white undersurface of the pileus hundreds of minute tubes (pores) could be observed; these extended out to the edge of the cap, and downward to the annulus. The larger cap now measured 2½ inches across in one direction by 2 inches in the other; the smaller cap 1½ inches x 1 inch. Each was 2 inches in height, and from being  $\frac{1}{2}$ -inch apart when first observed on 9th inst., they had now become joined along one edge.

On 16th March the yellow tint had mostly disappeared from the top of the larger cap, although a patch of deeper yellow or orange was exhibited in the centre, and a very pale yellow band near the circumference. This cap had a frilled appearance at the edge, extending in towards the



Fig. 1. "Native Bread" (*Polyporus mylitta*), exhibiting sporophores joined at part of circumference.

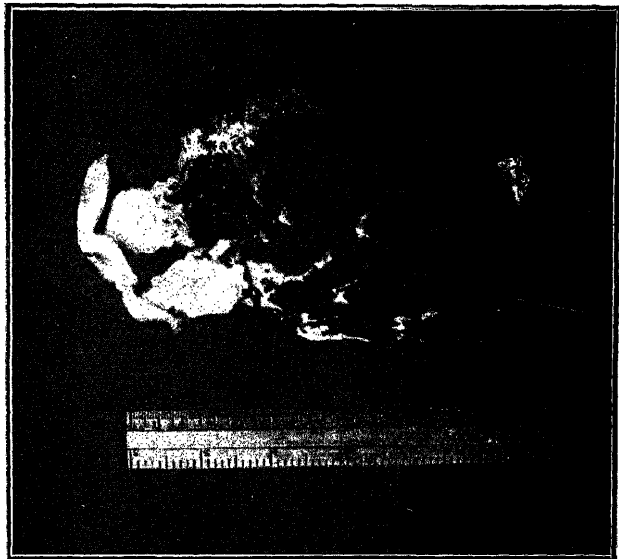
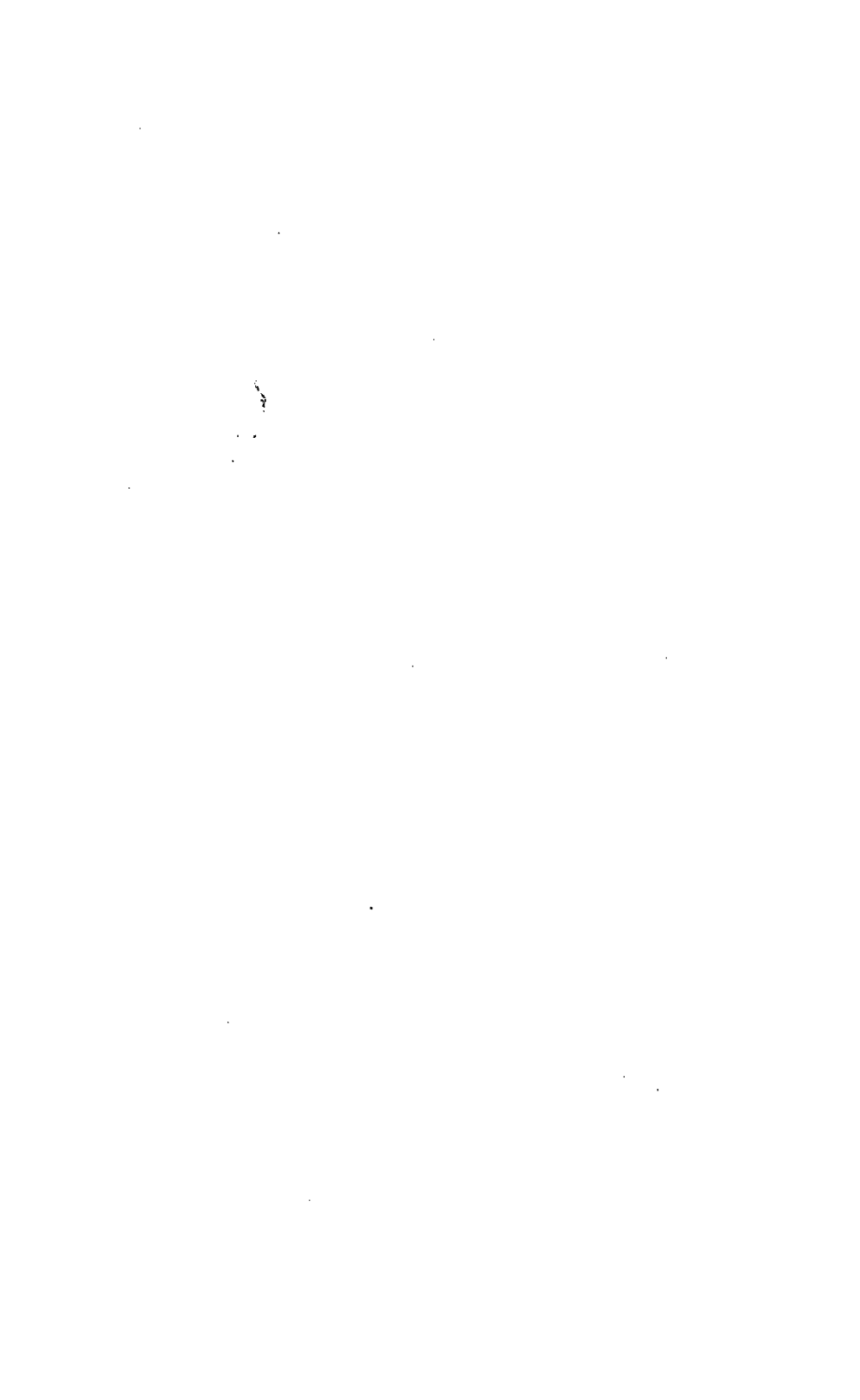


Fig. 2. Another aspect of same.



centre about  $\frac{3}{4}$  inch, and the smaller pileus began to show the same. The pores on the undersurface of the latter were now well developed, while those on the larger cap exhibited a more open appearance. The stems in both cases measured 1 inch in diameter. A strong mushroomy odour was observable.

On 18th inst. the pores had greatly developed, and showed well right down to the annulus; the stem thence to the base was quite smooth. The upper surface of the larger cap was now almost white again, there remaining only a yellow tinge where the orange patch had been, and traces of yellow near the circumference; the smaller cap was still of a pale yellow. The undersurfaces and stems of both are pure white.

It was noticed on the 22nd of the month that the pores were breaking down just above the annulus and falling on the "loaf" (sclerotium), no doubt carrying the spores with them. On the 28th this disintegration of the pores continued; those right under the surface of the cap have opened so much as to appear like a miniature honeycomb. Otherwise the sporophore has ceased to change, and the peculiar odour has almost disappeared. The sclerotium remains firm to the touch.

When these were first received on 3rd March, they had a distinct earthy odour.

A RE-EXAMINATION OF THE SKELETAL CHARACTERS OF *WYNYARDIA BASSIANA*, AN EXTINCT TASMANIAN MARSUPIAL.

By

FREDERIC WOOD JONES,

Melbourne.

Plate V. and Ten Text Figures.

(Read 8th September, 1930.)

Thirty years ago (P.Z.S. 1900, pp. 776-794) Sir Baldwin Spencer described and named the fossil Marsupial that had been brought to light by a fall of the cliff face at Table Cape, Tasmania.

Since that time *Wynyardia* has taken a definite place in all speculations concerning the phylogeny of the Marsupials, and has lent support to more than one hypothesis dealing with the history of the Australian Didelphians and their route of entry into the island continent.

Some years ago an examination of the cast of the fossil suggested to me the advisability of a reinvestigation of the characters of the animal, but the cast appeared to provide an inadequate basis upon which to conduct such a study.

During a visit to Hobart in 1925 I discussed with Mr. Clive Lord, Director of the Tasmanian Museum, the possibility of submitting the original specimen to a thorough re-examination and of providing a series of diopetrographic drawings of the fragments.

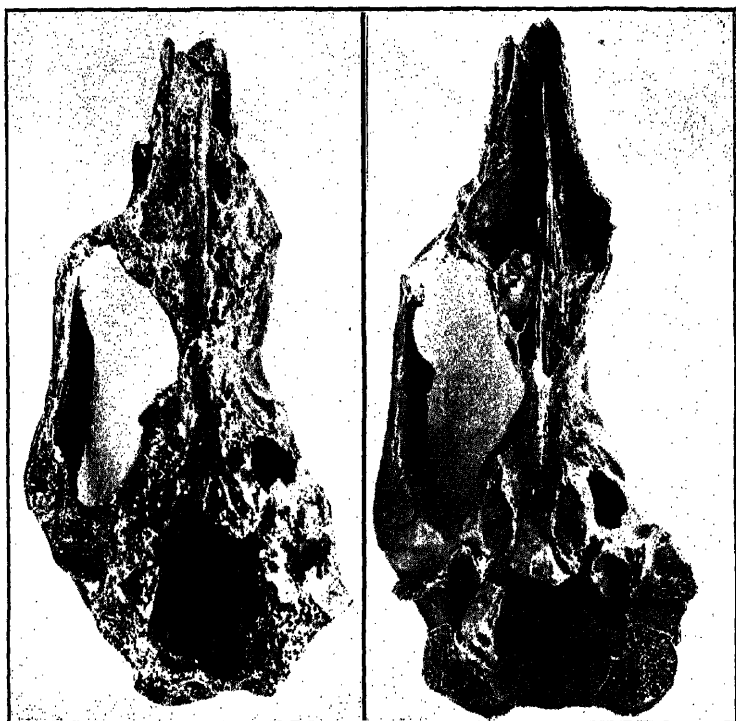
Upon my return to Australia in 1930 this was made possible by the kindness of the Director and Trustees of the Tasmanian Museum, who permitted me to have the most important fragments of the skeleton in my charge in Melbourne. I greatly appreciate the liberal policy that dictated this action, and rendered the present study possible.

GEOLOGICAL AGE OF THE SPECIMEN.

The specimen was originally "embedded in the Turritella-zone of the marine beds of Table Cape" (Johnston, Geology of Tasmania).

A

B



Basal view of the skull of (A) *Wynyardia* and of (B) *Trichosurus* mutilated to about the same extent.

Note the alveolus of the upper central incisor in both skulls.





At the time of its discovery, Australian geologists were in very general agreement that the Turritella-zone of Table Cape was definitely to be assigned to the Eocene period, and this deposit, as well as the Spring Creek beds of Victoria, were regarded as being "at the base of the series." (G. B. Prichard, "A revision of the fossil fauna of the Table Cape Beds, Tasmania." Proc. Roy. Soc. Vict., 1895, p. 74). By Tate, however, the Table Cape beds were, even at the time of the discovery of the fossil, diagnosed as most probably belonging to the Oligocene. (R. Tate, Trans. Roy. Soc. S. Aust., XXIII, pt. i., p. 107.) In the thirty years that have elapsed since Sir Baldwin Spencer wrote his paper, considerable attention has been devoted to the study of the Table Cape and Spring Creek beds; and it appears to be certain that we must revise our opinions as to the age of the fossil.

Chapman, in particular, has devoted a great deal of detailed study to beds of the so-called Janjukian age, and according to these latest and most intensive investigations the Janjukian deposits of Table Cape must be assigned to a period no older than the Miocene. (Frederick Chapman, Mem. Nat. Mus., Melb., No. 5, 1914; Brit. Ass. Sect. C. No. 144, 1914; Proc. Pan. Pac. Sc. Cong., 1923, p. 985.) By Howchin it is considered probable that the fossil belongs to a period no older than the Pliocene. ("The Building of Australia," Part II., 1928, p. 438.) It seems obvious, therefore, in the light of these most recent researches that we must regard *Wynyardia* as being a far more recent form than was supposed at the time of its original examination.

## THE SKULL.

### GENERAL CHARACTERS.

In general outline the portions of the skull preserved in the specimen resemble very strikingly the similar parts of a rather large skull of the Tasmanian form of the large Phalanger—*Trichosurus vulpecula fuliginosus*. With this animal it has been thought best to compare the fragments of the fossil, and figures 1 to 4, which are diptrographic drawings made to the same scale and drawn in the same plane, provide a basis for such a comparison. There are, however, some noteworthy differences between the two skulls.

Compared with *Trichosurus* the fossil shows:

- (a) A relatively larger brain case,

- (b) An unusually long anterior prolongation of the sagittal crest, and
- (c) A complete lack of inflation of any of the cranial bones.

The other features noted in the original description as being striking peculiarities, such as the large size of the lachrymal and squamosal elements, and the width of the nasals, are dealt with as they arise.

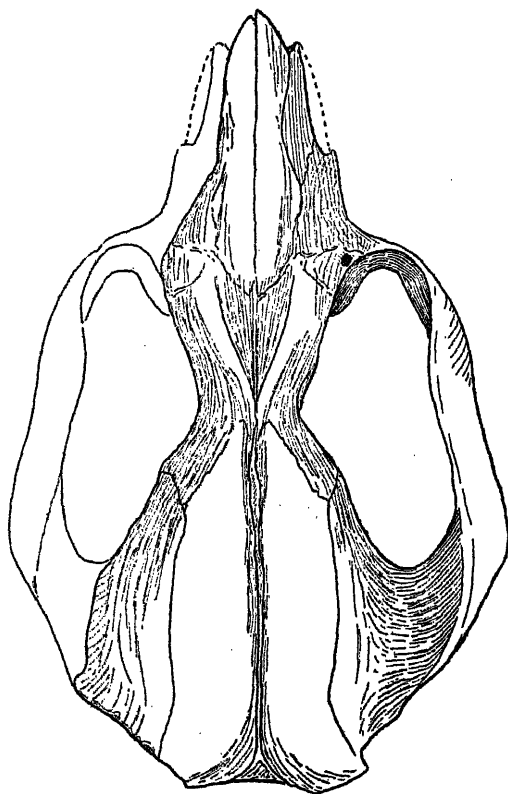


Fig. 1. *Wynyardia bassiana*.

Dorsal aspect of the skull. (Dioptrographic drawing.) (Natural size.)

In order to institute comparisons with the skulls of various recent Marsupials, Spencer took the nasal-occipital length of the fossil and the estimated maximum breadth across the zygomata. The relation established was 100 : 67,

and this high ratio of breadth to length was considered as a character that separated *Wynyardia* from the diprotodont marsupials and allied it with the polyprotodonts. I am inclined to think that 100 : 65 would be a more accurate estimate for the ratio in *Wynyardia*. When comparison is made with the skulls of various diprotodonts it is at once apparent that *Wynyardia* is by no means peculiar in this ratio.

Examples of *Trichosurus vulpecula fuliginosus* show a ratio of 100 : 61, and *Bettongia lesueri* 100 : 63. But the ratio of the fossil is exceeded by *Æpyprymnus rufescens* with 100 : 69, by *Petaurides volans* with 100 : 70, and by *Petaurus breviceps* with a slightly higher ratio. The cranial cavity of the fossil is relatively large when comparison is made with certain recent marsupials; it is larger than that

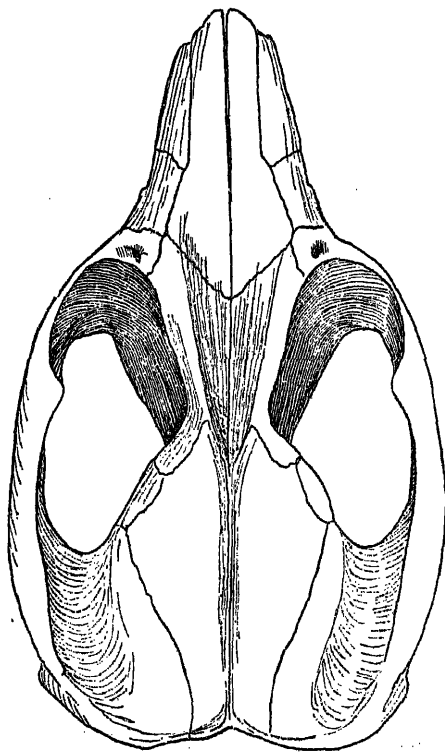


Fig. 2. *Trichosurus fuliginosus*.  
Dorsal aspect of the skull. (Diopetrographic drawing.) (Natural size.)

of the skull of *Trichosurus vulpecula fuliginosus* selected for comparison; but that "the relative size of the brain was "greater than in existing marsupials" cannot be maintained when comparison is made with many types not included by Spencer in his survey.

Spencer's figure for the length, breadth, and height of the cranial cavity of the fossil are 58, 33, and 26. If we take *Æpyprymnus*, the same measurements (adjusted for an equivalent skull length of 100) are as high as 71, 47, and 36. *Wynyardia* indeed can claim but little distinction even from many specimens of *Trichosurus* in this regard, for the equivalent measurements of some skulls are 58, 32, and 25.6. Certainly on the strength of this evidence it is not just to claim, as Spencer does, that the brain of the marsupials has possibly "retrogressed, from a former higher development in *Wynyardia*."

In reviewing the whole gross characters of the skull it must be admitted that singularly few really noteworthy characters are displayed which tend to differentiate it from that of a modern Tasmanian phalanger. That it shows characters unlike those of any recent marsupial, or that it possesses features typical of, or peculiar to, the Polyprotodonts, as claimed by its original describer, are contentions that the findings of the present investigation do not support.

#### THE INDIVIDUAL CRANIAL BONES.

##### *The Pariotic.*

In the original description it is said that the structure of the parietal "is quite unlike that of any other marsupial." The outstanding peculiarities upon which stress is laid are its relative small size and its distinctions in form. On comparison with the same element in a skull of *Trichosurus* of comparable size, it can hardly be maintained that the parietal of the fossil is unduly small, when allowance is made for the portions that have been broken and lost. Nor is there any conspicuous difference in the form of the bone itself, although the much more complete encapsulation of the floccular fossa in the recent animal causes a somewhat different general appearance of the topography of the part. Both the ossified tentorium and the capsule of the floccular fossa appear to be diminished in the fossil, even when allowance is made for the breakage of these thin pieces of bone.

To the present author it seems that it is the differences manifested in the surrounding parts, particularly in the

excavation for the floccular fossa, far more than any real differences in the form of the periotic itself, that account for the rather different appearances of this region of the skull when *Wynyardia* is compared with *Trichosurus*.

In *Bettongia*, *Potorous*, and *Æpyprymnus*, where the tentorial ossification and the excavation of the floccular fossa are less than in *Trichosurus*, the gross likeness to *Wynyardia* is greater; but this affects the general topographical resemblance rather than the intimate features of the periotic, and with these the parallel would certainly seem to be with *Trichosurus*.

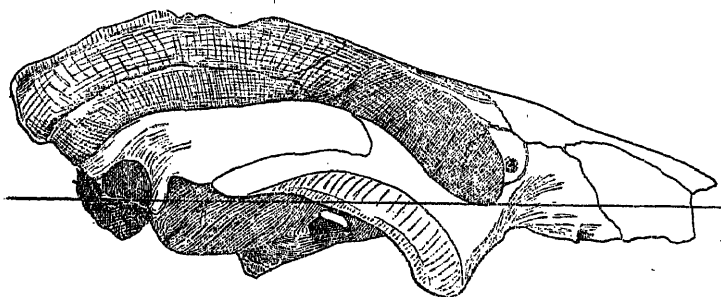


Fig. 3. *Wynyardia bassiana*.

Lateral aspect of the skull. (Dioptrographic drawing.) (Natural size.)

So exact is this parallel that it is impossible to cite any character in which the periotic of the fossil differs from a similarly mutilated bone of a recent specimen of *Trichosurus*.

#### *The Glenoid Fossa.*

The characters of the glenoid fossa were originally described as having features most nearly resembling those present in *Thylacinus*. This comparison was instituted mainly on the features displayed by the post-glenoid process. In the form of the post-glenoid process, and especially in its independence from the tympanic, affinities were claimed with the polyprotodonts generally. The form of the process is, however, typical of that of the majority of the diprotodonts, and it is difficult to determine any feature that distinguishes it from the corresponding portion of bone in *Trichosurus*. Its supposed distinction from that of *Trichosurus* lies in its apparent independence of the tympanic. It must be remembered, however, that fusion of the post-glenoid process and the posterior wall of the external auditory meatus is by no means typical of the diprotodonts, for in many forms it

never takes place, and when it does occur it is a purely secondary process carried out only with advancing age. Even in the adult skull of *Trichosurus* the separation of the two elements is easily effected, and in *Æpyprymnus* and in the Macropods generally, independence of the post-glenoid process is maintained throughout life. The transverse elongation of the glenoid cavity provides no differential character from the diprotodont condition; it does not exceed that typical of *Trichosurus*. (See Plate V.)

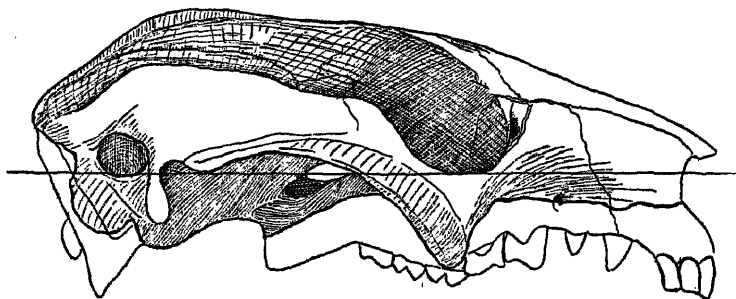


Fig. 4. *Trichosurus fuliginosus*.

Lateral aspect of the skull of an adult male. The parts missing from the skull of *Wynyardia* are indicated in outline. (Dioptrigraphic drawing.) (Natural size.)

### *The Squamosal.*

In the original description much stress is laid upon the great size of the squamosal: "The squamosal is indeed larger than in any existing or fossil marsupial yet known; and its forward extension completely prevents the alisphenoid from coming into contact with the parietal." The anterior limits of the squamosal are difficult to detect in the fossil, and this is so because, in all probability, the suture line between the squamosal and the alisphenoid is obliterated.

Such fusion of the squamous and alisphenoid is of frequent occurrence in the skulls of mature examples of *Trichosurus*. The marking, which, in the original description, is taken as forming the separation between the two elements, is, in the present interpretation, assumed to represent the vertical portion of the pterygoid or infratemporal ridge. (See Fig. 5.) This ridge is situated upon the alisphenoid, and a marking almost identical in detail with that of the fossil is present in *Phalanger*; whilst in *Tricho-*

*surus*, although the horizontal ridge is always present, the vertical portion is variable.

Since then it is assumed that the alisphenoid-squamosal junction postulated in the original description is in fact the pterygoid ridge on the alisphenoid, it remains to be determined if any of the suture line between the two bones has escaped complete obliteration and can be detected in the fossil. I am of the opinion that traces of the suture may be followed upon the lateral wall of the skull on the left side, and in front of the glenoid fossa upon the right side.

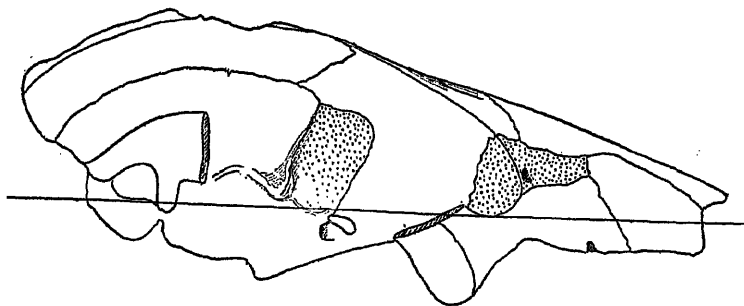


Fig. 5. *Wynyardia bassiana*.

The alisphenoid and lachrymal elements as determined in the original investigation. (Natural size.)

It is to be noted that in the original description, when dealing with the features of the cranial cavity, the following identification is made:—"The sella turcica has no posterior clinoid process, and from the foramen rotundum of each side a well-marked groove leads back to the gasserian fossa, the outer edge of the groove being formed by the projecting ridge of bone which is developed from the alisphenoid in the tentorial plane."

There can be no doubt as to the correctness of this diagnosis; and the fact that the ridge is present on the inner side of the bone diagnosed as squamosal on the outside of the skull, strengthens the present claim that the suture line between the squamosal and alisphenoid was wrongly determined in the original description. It is, therefore, claimed that the alisphenoid element is determined as shown in figure 6, a disposition that differs in no essential way from that typical of *Trichosurus*, *Phalanger*, and many other living diprotodonts.



With regard to the squamosal suture, the fact that there "is a general parallelism of the upper part of the suture of the squamosal with the sagittal crest" is justly emphasised in the original description.

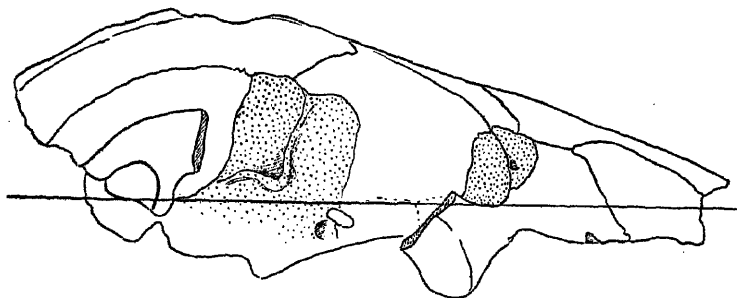


Fig. 6. *Wynyardia bassiana*.

The alisphenoid and lachrymal elements as determined in the present investigation. (Natural size.)

Herein the fossil differs considerably from the adult *Trichosurus*. (See Figs. 1 & 2.) But it must be observed that the convergence of the caudal extremities of the sutures in *Trichosurus* is a very variable feature, and one depending upon age and the degree of inflation of the temporal. In the young *Trichosurus* the two sutures are situated as in *Wynyardia*; and in *Phalanger* the condition is practically identical even in the adult. A similar parallel disposition of the squamous sutures is also present in *Bettongia*, *Potorous*, and *Aepyprymnus* among the diprotodonts.

The most pronounced distinction of the temporal bone of the fossil is the entire absence of any inflation with air cells, such as is a conspicuous feature in the skulls of most adult members of the *Phalangeridae*.

#### *The Lachrymal.*

The description of the lachrymal is somewhat confused in the original account. Among the striking features of the skull (pp. 778-9) there is included:—"The large size of the lachrymals, which meet the nasals and prevent the maxillæ from coming into contact with the frontals." This is a perfectly correct statement, but it constitutes no peculiarity, for the condition described is variably present in *Trichosurus* and in *Phalanger*; and as it exists in *Wynyardia* it is a common feature in the skulls of both these living genera. But on page 781 it is said:—"The lachrymals

"are of large size, and extend upon the face to such an extent that, owing partly to the width of the nasal bone, they come into contact with the latter, and so prevent the upward process of the maxilla from reaching the nasal." It is further said that:—"This feature is also met with in *Phascolomys*," but in that animal the lachrymal does not meet the nasal, and the maxilla articulates with both the frontal and the nasal. It is, therefore, somewhat difficult to determine if the original identification of the lachrymal element was that it only extended forwards so as to exclude the maxilla from contact with the frontal or if it was supposed that it went still further and excluded the maxilla from contact with the nasal. (See Fig. 5.) There is no sort of distinction for *Wynyardia* in the first case, and it can therefore only be supposed that the second diagnosis was intended.

Fortunately, there can be no sort of doubt as to the condition present in the fossil. The suture lines are clearly defined, and are correctly placed by the artist in the plates accompanying the original description. The facial portion articulates with the frontal and the nasal, and excludes the maxilla from contact with the frontal; and that is the state of affairs very usual in *Trichosurus*. (See Fig. 6.) The lachrymal bone of the fossil is, therefore, in every way similar to that of the living diprotodonts, and has an actual identity with the bone as it occurs in the living *Trichosurus*.

#### *The Frontal.*

The frontals in their outline and articulations are almost precisely as in *Trichosurus*. The fact that they are wider in their cranial than in their facial portion, as stressed in the original description, is important; but it cannot be even in adult examples of *Trichosurus*, and in the skulls of admitted as in any way a distinction peculiar to *Wynyardia* among the marsupials. The condition is met with at times younger animals it is constant. The cranial width of the frontal portion of the skull of *Wynyardia* exceeds that of any actual skull of *Trichosurus* with which I am able to compare it, and the condition is brought about partly by the somewhat more caudal extension of the frontals in the fossil than in the recent forms. In such diprotodont genera as *Potorous* and *Aepyprymnus*, however, the breadth of the cranial portion of the frontal always exceeds that of the facial portion in a very marked degree.

It is, therefore, not just to claim, as is done in the original description, that in this feature *Wynyardia* differs from all known recent marsupials.

The excavation of the frontals by the anterior bifurcation of the sagittal crest differs only in degree from that present in recent *Phalangeridæ*; and it is difficult to see in it any definite approach to the condition seen in the polyprotodonts.

#### *The Nasal.*

The nasals differ in no way from those of *Trichosurus*. The expansion of the caudal extremities (which was claimed as a striking peculiarity in the original description) is in the same region as, and does not exceed, that of *Trichosurus*. The long anterior extension of the nasals in advance of the premaxillæ is exactly as in *Trichosurus*, and is a feature diagnostic of the *Diprotodontia*.

#### *The Maxilla.*

The maxilla in every feature agrees with that of *Trichosurus*, save that the infraorbital canal is situated further forwards in the fossil. In *Trichosurus* the foramen is usually situated about mid-way between the anterior and posterior borders of the bone; in *Wynyardia* it is situated at about the junction of the anterior third with the posterior two-thirds of this distance.

#### *The Premaxilla.*

The premaxillæ are, as Spencer justly remarks, "approximating most in form to those of *Trichosurus*." From the premaxillæ alone it would be justifiable to deduce the fact that the animal had no real resemblance to any polyprotodont, and that its incisors must have been large and of the type usual in the diprotodonts. Spencer continues: "It is most unfortunate that the lower part of the premaxillæ should have been broken away at such a level as to leave no indication of the exact nature of the teeth." As a matter of fact the premaxilla still carries very decisive evidence of the nature of the upper central incisor. A small area of the alveolar cavity for this tooth is perfectly preserved and retained in the specimen; indeed it is distinctly recognisable in the figure (Plate XLIX., Fig. 2) illustrating the original description by Spencer.

This portion of the alveolus remains when the premaxilla of a recent skull of *Trichosurus* is fractured at the same level. (See Plate V.)

In the light of this evidence it appears to be certain that *Wynyardia* was, in fact, a typical diprotodont, and that it possessed an upper central incisor of very much the same type as that present in the living *Trichosurus*.

#### SUMMARY OF CRANIAL CHARACTERS.

The whole of the characters of the skull are best dealt with in the form of a summary of the differential characters as determined in the original investigation with comments upon them in the light of the present re-examination.

A. Characters in which the skull of *Wynyardia* was claimed to differ from that of all recent marsupials.

- (1) The greatest breadth of the frontals is in the cranial part.

*Comment.* This condition is typical of many diprotodont marsupials.

- (2) The anterior position of the infraorbital foramen.

*Comment.* The position is very variable in existing genera of diprotodont marsupials.

- (3) The structure of the periotic.

*Comment.* No real structural differentiation from the typical marsupial form of the bone.

- (3) The great relative size of the cranial cavity.

*Comment.* Considerably exceeded in some living diprotodont marsupial genera.

Finally, every peculiar feature of the foramina and of the general form and articulations of the constituent bones of the skull is so typically that of a didelphian mammal that there can be no hesitation in diagnosing it unreservedly as belonging to that sub-class of the mammalia.

B. Characters in which the skull of *Wynyardia* was claimed to differ from the *Diprotodontia* and resemble the *Polyprotodontia*.

- (1) Proportionate length to breadth of skull 100 : 67—decidedly greater relative width than is present in diprotodonts.

*Comment.* Relative width exceeded in many living diprotodonts.

- (2) Lambdoidal crest well developed.

*Comment.* The same feature present in *Trichosurus*.

- (3) Sagittal crest well developed.

*Comment.* The same feature present in *Trichosurus*.

- (4) The form of the zygomatic arches.

*Comment.* No real distinction from many diprotodonts.

- (5) The transverse elongation of the glenoid fossa. The downward produced plate of bone which forms the boundary is not connected with any structure forming part of the auditory passage.

*Comment.* Exactly as in many typical diprotodonts.

Finally, it must be added that the characters of the premaxillæ; the remaining portion of the alveolus for the upper central incisor; the absence of any alveolus for an enlarged canine (which would certainly have been evident in the broken maxilla); and the long overhang of the nasals, definitely rank the skull of *Wynyardia* among the specialised Australian diprotodonts.

#### *The Mandible.*

The fragment of the lower jaw has been broken in a singularly unfortunate manner, for the alveolus of only one tooth is to be identified beyond all doubt. Such characters as are definitely shown by the fragment are in entire agreement with the supposition that the whole mandible was formed upon the general lines of the same bone of *Trichosurus*. (See Fig. 7.) It is difficult to appreciate the features that, in the original description, led to the conclusion that the jaw was of a peculiar type, or that it showed resemblance to that of *Perameles*. The broken alveolar cavity for the roots of the third molar is clearly retained in the fragment, but there is no indication of the sockets of the anterior cheek teeth. With regard to the lower central incisors it is said in the original description (p. 784) that:—"Either there were "no largely-developed incisors, or else the symphysis was "a remarkably long one, as there is not a trace of any "sockets at the anterior end." It may be that the knowledge of the existence of *Trichosurus*-like upper central incisors

has influenced the views of the present writer, and so biased him in favour of a possibility of detecting the alveolus of a large lower incisor. Such a consideration is borne in mind throughout this discussion. A mandible of *Trichosurus*

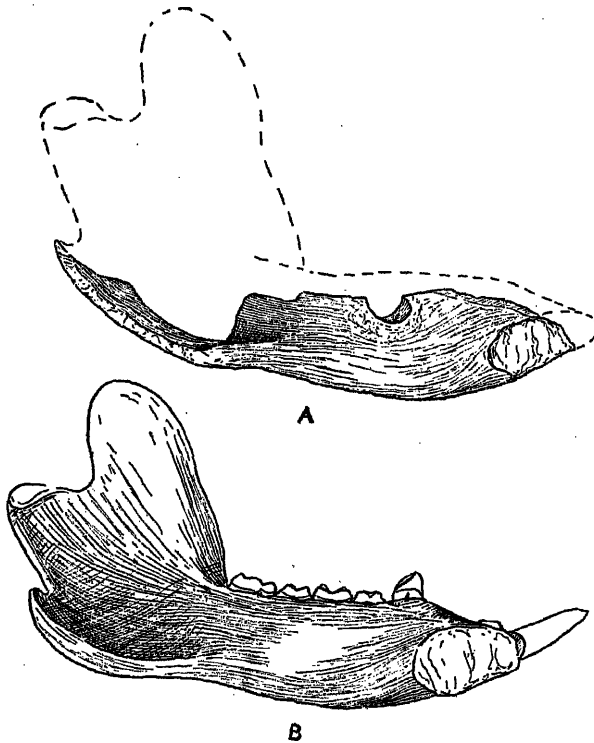


Fig. 7. Mandible of *Wynyardia* (A) and *Trichosurus* (B). (Diotrographic drawing.)

The probable missing parts of *Wynyardia* are inserted in dotted line. (Natural size.)

mutilated to the same extent as the fragment of *Wynyardia* appears to show very clearly that the incisor alveolus of the fossil is filled completely either with the mineralised matrix, or with the incisor root, but that, nevertheless, the boundaries of the alveolar cavity are more or less clearly defined.

The point must remain in some doubt; but the area occupied by what is here diagnosed as matrix, or incisor root, coincides so exactly with the empty incisor socket of the jaw of *Trichosurus*, i.e., from the region of the symphysis

to the anterior end of the exposed dental canal, that there seems to be a high degree of probability that the absent lower incisor did not depart widely, if at all, from the type present in the living *Phalanger*.

As for the curious depression that involves the alveolar margin in the region of the second lower molar tooth, it is almost impossible to conceive of its being a normal anatomical feature. As a normal feature it finds no parallel anywhere among the mammalia, and the suggestion that it corresponds to some peculiarly-developed tooth of the maxillary series has no support from the whole experience of mammalian morphology. In the original description the pathological nature of the depression was considered and rejected; but, despite this finding, it would seem that the most probable diagnosis was an alveolar abscess cavity at the root of the second molar tooth. Such abscess cavities are by no means uncommon in the diprotodonts, both in the wild state and in captivity; and the depression, with its thickened margins, presents characters practically identical with those of root abscess cavities in examples of *Petrogale*, *Onychogale*, and *Macropus* in the writer's possession. Again, in this, as in other characters, sea wear must be taken into account.

#### THE VERTEBRAL COLUMN.

##### *The Axis Vertebra.*

The axis vertebra, though somewhat damaged, is preserved sufficiently completely to permit some very definite conclusions as to its form. A considerable degree of importance was attached to the characters of this bone in the original description, and it was concluded that in several ways rather wide differences were shown from the type present in recent marsupials.

Compared with the corresponding bone of *Trichosurus*, it is seen to be generally more massive, more strongly ridged, and to possess transverse processes that are not sloped so markedly in a caudal direction. It may be open to doubt if the whole of the delicate transverse process is present in the fossil, for, although its extremity shows no obvious sign of being broken, it must be remembered that the skeleton was exposed to the action of the sea long enough to permit a barnacle 18 mm. in diameter to grow upon the sacral fragment.

Although the slope of this transverse process is by no means so acute as it is in *Trichosurus*, it can hardly be claimed that its axis "is nearly at right angles to the body of the vertebra" (p. 790). It would seem more correct to say that, whereas in *Trichosurus* the angle is in the region of 30, in *Wynyardia* it is about 40. (See Fig. 8.)

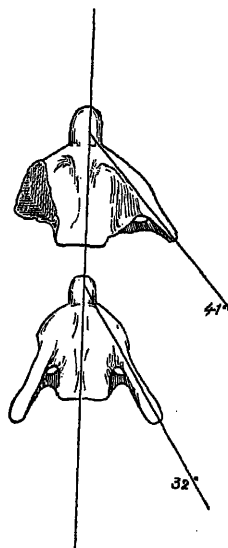


Fig. 8. The axis vertebra of *Wynyardia* (above) and *Trichosurus*. (Dioptrographic drawing.) (Natural size.)

#### *The Sacrum.*

The sacrum is too much broken to permit any valid deductions as to its original form.

#### *The Vertebrae.*

Only fragments of isolated vertebrae were submitted for re-examination (the remainder being embedded in the matrix). Among these portions there were no recognisable characters of diagnostic value.

#### *The Pelvis.*

Although the skull appears to show few, if any, characters that differ in any fundamental way from those of the living *Trichosurus*, the pelvis departs considerably from the type characteristic of the *Phalangeridae*. (See Fig. 9.)



Its distinctions are mainly confined to the ilium; for the ischium appears to have been, in every essential character, an enlarged and more massive model of the *Trichosurus* type. The ilium differs from that of *Phalangeridae* in its more prismatic form; the lateral surface being strongly marked off from the anterior and posterior surfaces. In this, and in other characters where a departure is seen from the phalangerine condition, an approach is made towards that seen in the macropods.

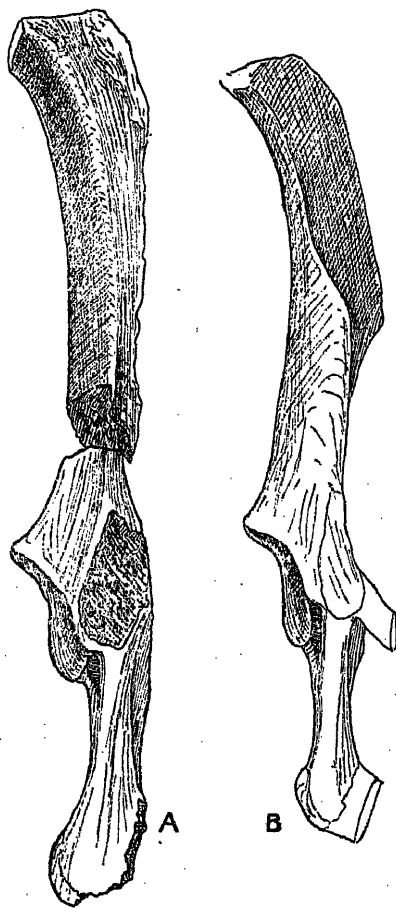


Fig 9. Right side of the pelvis of (A) *Wynyardia* and (B) *Trichosurus*.  
(Dioptrographic drawing.) (Natural size.)

The sacral articular surface is, unfortunately, broken away, as is also the whole of the pubic portion of the pelvis. From the existing portions it would seem most probable that the greatest departure from the *Trichosurus*-type lay in the robust nature of the *Wynyardia* pelvis, combined with a disposition of the gluteal muscles that differed essentially from that present in the living arboreal *Phalangeridæ*.

*The Femur.*

The greatest distinction of the *Wynyardia* femur is its massive build. When compared with the corresponding bone

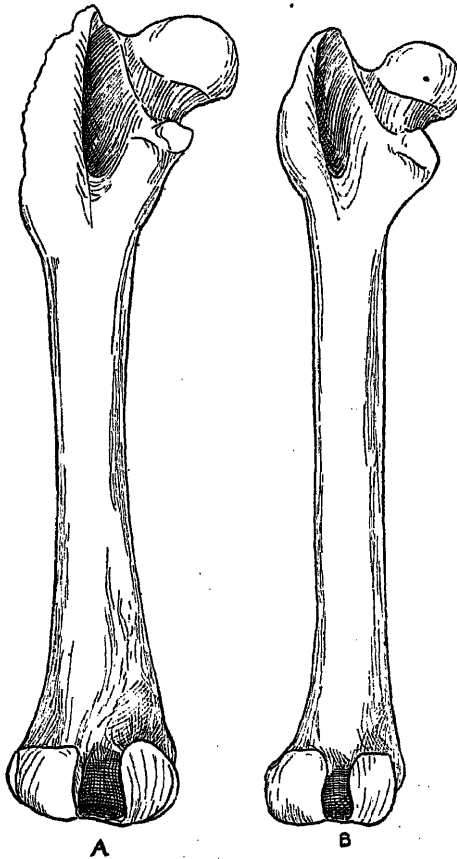


Fig. 10. Posterior aspect of left femur of (A) *Wynyardia* and (B) *Trichosurus*. (Dioptrigraphic drawing.) (Natural size.)

of *Trichosurus* it is at once obvious that, though the femur is no longer than that of the living animal, it is in every way far more robust. (See Fig. 10.) Apart from this general distinction there is the special character, to which Spencer called attention—the relative great width of the internal condylar facet. But, although this feature constitutes a well marked distinction from the condition met with in *Trichosurus*, it is not without its parallel in such terrestrial diprotodonts as *Macropus*.

In another feature, the flattened and down-bent head of the femur, a closer approach is made to the terrestrial macropods than to the arboreal phalangers. We may, therefore, say that, though the femur departs from the form typical of the phalangers it displays no non-marsupial characters, such as were originally claimed for it.

#### *The Tibia.*

Save for its massive build and the fact that the inner condyle (in harmony with that of the femur) is unduly large, the tibia of *Wynyardia* presents no essential difference from that of *Trichosurus*.

The fibula was not included among the bones submitted for re-examination.

From those portions of the vertebral column and of the pelvis and the pelvic limb submitted to re-examination it is not possible to deduce any non-marsupial characters or any that preclude the conclusion that *Wynyardia* was definitely a fully differentiated Australian diprotodont. We may deduce, however, that it was a sturdily-built creature, considerably heavier than the living *Trichosurus*, and probably differing from that animal in habit and in bodily poise.

#### SUMMARY AND CONCLUSIONS.

The re-examination of the remains of *Wynyardia bassiana*, and a consideration of the more recent findings of Australian palæontologists, permit of the following conclusions:—

- (1) The animal must be regarded as a member of the Janjukian Miocene or Pliocene fauna, and not as an early or basal Eocene form.
- (2) It is, in all its essential characters, a typical member of the didelphian Sub-Class of the Mammalia. It shows no character that differentiates it from

recent marsupials (and it must be remembered that one of the "marsupial bones" was present when it was first described by Spencer).

- (3) It shows no feature that excludes it from the *Diprotodontia*, and it must be regarded as already a fully-developed and typical Australian diprotodont, and in no way as an annectant from between *Polyprotodontia* and *Diprotodontia*.
- (4) It shows so many resemblances to the characters of the living genus *Trichosurus* that it must be considered as an ally of the Phalangiers; but
- (5) The sturdiness of its limb bones and the differences in the muscular impressions make it probable that its gait and habit differed markedly from those of the modern lightly-built arboreal animals.

These findings are, in the main, in direct opposition to those of the original examination made thirty years ago.

# THE ROYAL SOCIETY OF TASMANIA

## ABSTRACT OF PROCEEDINGS

1930

24TH MARCH, 1930.

### *Annual Meeting.*

The Annual Meeting was held on the 24th March, 1930, at the Society's Rooms, Tasmanian Museum, Hobart, Mr. L. Rodway, C.M.G., presiding.

The Annual Report and Financial Statement were read and adopted.

The following were elected Members of the Council for 1930:—Dr. A. H. Clarke, Dr. W. L. Crowther, Messrs. W. H. Clemes, W. H. Cummins, A. V. Giblin, A. N. Lewis, L. Rodway, E. E. Unwin, F. E. Ward, C. E. Lord (*ex officio*).

Mr. Walter E. Taylor was elected honorary auditor.

It was announced that Dr. Clarke and Mr. Rodway did not seek re-election as Vice-Presidents, and that the President (His Excellency Sir James O'Grady, K.C.M.G.) had appointed Dr. W. L. Crowther and Mr. A. N. Lewis as Vice-Presidents for 1930.

29TH MARCH, 1930.

A meeting was held at the Society's Rooms on the 29th March, 1930, His Excellency Sir James O'Grady presiding.

### *Illustrated Lecture.*

Rear-Admiral E. R. G. R. Evans, D.S.O., delivered an illustrated lecture on "Scott's Last Antarctic Expedition."

### *Conversazione.*

At the conclusion of the Lecture a Conversazione was held in the Art Gallery.

14TH APRIL, 1930.

A meeting was held at the Society's Rooms, Dr. W. L. Crowther, Vice-President, presiding.

*Illustrated Lecture.*

Mr. H. F. Comber delivered an illustrated lecture, "A Botanist in the Andes."

12TH MAY, 1930.

A meeting was held at the Society's Rooms, Dr. W. L. Crowther, Vice-President, presiding.

The following members were elected:—Colonel J. E. C. Lord, Mr. W. R. Young, Mr. A. McIntyre, Mr. C. E. Smith, Mrs. Ronald Read, Mr. S. W. Steane, Mr. S. Fox, Miss C. Travers, and Miss I. D. Travers.

*Papers.*

The following papers were read:—

"Tasmanian Cycadophyta." By H. H. Scott.

"On the Sporophore of *Polyporus mylitta*." By H. Stuart Dove.

*Illustrated Lecture.*

"Ore Deposits." By A. N. Lewis, M.C., LL.M.

9TH JUNE, 1930.

A meeting was held at the Society's Rooms, Mr. A. N. Lewis, Vice-President, presiding.

The following members were elected:—Mr. E. Parkes and Mr. C. Mitchell.

*Paper.*

The following paper was read:—

"A Revision of the Class Insecta." By R. J. Tillyard, D.Sc., F.R.S.

*Illustrated Lecture.*

"Notes on the Origin of Coal and Natural Oils." By Mr. A. McIntosh Reid.

14TH JULY, 1930.\*

A meeting was held on 14th July, Mr. A. N. Lewis presiding.

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\*This was the last meeting held in the Argyle Street room. Following this meeting, the Library and meeting room of the Society was moved to a larger room in the Museum buildings facing Macquarie Street.

*Illustrated Lecture.*

"The Aims and Objects of Forestry." By Mr. S. W. Steane, Conservator of Forests.

8TH SEPTEMBER, 1930.

A meeting was held in the new Library and Meeting room of the Society. His Excellency the Governor, Sir James O'Grady, K.C.M.G., President of the Society, presided over an attendance of approximately 300 members and guests.

*Official Opening of new Library and Meeting Room.*

His Excellency formally declared the new Library and Meeting Room open.

*Paper.*

The following paper was read:—

"A Revision of the skeletal characters of *Wynyardia bassiana*." By Professor F. Wood-Jones, M.D., F.R.S., &c.

*Lecturettes.*

"The value of the Royal Society to the Community." By E. E. Unwin, M.Sc.

"The History of the Royal Society of Tasmania." By A. N. Lewis, M.C., LL.M.

*Presentation of the Royal Society of Tasmania Medal.*

Dr. W. L. Crowther, on behalf of the Council of the Society, moved that the Royal Society of Tasmania Medal be awarded to Mr. Clive Lord, and in doing so referred to Mr. Lord's work on behalf of the Society, which, in the opinion of the Council, warranted such recognition as the Council proposed the Society should give.

The motion was seconded by Mr. F. E. Ward and carried.

His Excellency the Governor presented the medal to Mr. Lord on behalf of the Society.

*Conversazione.*

At the conclusion of the meeting a conversazione was held in the Art Gallery.

13TH OCTOBER, 1930.

A meeting was held at the Society's Rooms, Tasmanian Museum, Mr. A. N. Lewis presiding.

The following were elected members:—Mr. J. B. Scott, Mr. John Taylor, Mr. J. R. Crane, and Miss H. Power.

*Illustrated Lecture.*

"The Conservation of Fauna with Special Reference to the Animals of Tasmania." By Clive Lord.

17TH NOVEMBER, 1930.

A meeting was held at the Society's rooms. The President of the Society, His Excellency Sir James O'Grady, presided, supported by the Vice-Presidents and the Honourable the Premier (Honourable J. C. McPhee). The attendance was such as to fill the Meeting Room.

The President introduced Sir Douglas Mawson, and in doing so expressed the wish that he and his fellow members of the British Australian New Zealand Research Expedition might have a pleasant and profitable voyage in the R.S.S. *Discovery*.

*Illustrated Lecture.*

"Life in the Antarctic." By Sir Douglas Mawson, Kt., O.B.E., B.E., D.Sc., F.R.S.

*Conversazione.*

At the conclusion of the lecture a conversazione was held in the Art Gallery.

1ST DECEMBER, 1930.

A meeting was held at the Society's Rooms, The Tasmanian Museum.

The following were elected members:—Dr. Terence Butler, Mrs. Terence Butler, Dr. Christine Walch, Mr. E. D. F. Kemp, Mrs. Lloyd Oldmeadow, and Mrs. Geoffrey Chapman.



# THE ROYAL SOCIETY OF TASMANIA

1930

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**Patron:**

HIS MAJESTY THE KING.

**President:**

HIS EXCELLENCY SIR JAMES O'GRADY, K.C.M.G.

**Vice-Presidents:**

W. L. CROWTHER, D.S.O., M.B., V.D.

A. N. LEWIS, M.C., LL.D.

**Council:**

(Elected March, 1930)

A. H. CLARKE, M.R.C.S., L.R.C.P.  
(Chairman)

W. H. CLEMES, B.A., B.Sc.

W. E. L. CROWTHER, D.S.O., M.B.  
V.D.

W. H. CUMMINS

A. V. GIBLIN.

A. N. LEWIS, M.C., LL.D.

CLIVE LORD, F.L.S., C.M.Z.S.

L. RODWAY, C.M.G.

E. E. UNWIN, M.Sc.

F. E. WARD.

**Standing Committee:**

W. H. CLEMES, A. N. LEWIS, CLIVE LORD.

**Hon. Treasurer:**

A. V. GIBLIN.

**Editor:**

CLIVE LORD

**Auditor:**

WALTER E. TAYLOR, F.F.I.A., F.I.A.S.

**Secretary and Librarian:**

CLIVE LORD

## LIST OF MEMBERS

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### Honorary Members:

- David, Sir T. W. Edgeworth, K.B.E., C.M.G., B.A., F.R.S., F.G.S., Emeritus Professor of Geology and Physical Geography in the University of Sydney. "Coringah," Sherbrooke Road, Hornsby, N.S.W.
- Mawson, Sir Douglas, Kt., O.B.E., B.E., D.Sc., F.R.S. Professor of Geology and Mineralogy, the University, Adelaide.
- Wood-Jones, Professor F., M.B., D.S., M.R.C.S., L.R.C.P., D.Sc., F.R.S. The University, Melbourne.
- Tillyard, R. J., M.A. Sc.D. (Cantab.), D.Sc., F.R.S., F.N.Z. Inst., F.L.S., F.G.S., F.E.S., C.M.Z.S. Chief of the Division of Economic Entomology, C.S.I.R., Canberra City, F.C.T.

Year of  
Election.

### Corresponding Members:

- 1901 Benham, W. B., M.A., D.Sc., F.R.S., F.Z.S. Professor of Biology, University of Otago, Dunedin, N.Z.
- 1892 Bragg, Sir W. H., M.A., F.R.S. Director of the Royal Institution, Albemarle Street, London.
- 1901 Chapman, Professor R. W., M.A., B.C.E. The University, Adelaide.
- 1923 Pulleine, R., M.B. 163 North Terrace, Adelaide.
- 1892 Thomson, Hon. G. M., M.L.C., F.L.S. 99 Eglinton Road, Dunedin, N.Z.
- 1901 Wall, Professor A., M.A. Canterbury College, Christchurch, N.Z.

### Life Members:

- 1918 Avery, J. Private Bag, Hobart.
- 1908 Baker, H. D. American Consular Service, Washington.
- 1890 Foster, Lieutenant-Colonel Henry. "Merton Vale," Campbell Town.
- 1905 Grant, C. W. "High Peak," Huon Road.
- 1896 Sprott, G., M.D. Town Hall, Hobart.

## Members:

Year of Election.	
1921	Anderson, G. M., M.D., C.M. 56 Clare Street, New Town.
1921	Allen, D. V., B.Sc. Technical School, Launceston.
1928	Allport, Henry. 111 Macquarie Street, Hobart.
1926	Atkins, C. N., M.B., B.S., D.P.H. 145 Macquarie Street, Hobart.
1928	Avery, David. Geeveston, Tasmania.
1921	Baker, Hon. H. S., LL.M., D.S.O. Messrs. Finlay, Watchorn, Baker, and Turner, Murray Street, Hobart.
1921	Barr, J. Stoddart, M.D. (Glasgow). Lower Sandy Bay.
1926	Barrett, Rev. W. R. Christ College, Park Street, Hobart.
1929	Baudinet, Miss D. 336 Murray Street, Hobart.
1918	Bellamy, H., J.P., M.Am.Soc. C.E., M.I.Mech.E., F.R.San. I. Government Hydraulic Engineer. Adelaide.
1924	Bennett, H. W., L.D.S., D.D.S. Brisbane Street, Launceston.
1909	Blackman, A. E. 26 Warwick Street, Hobart.
1920	Blaikie, T. W. Practising School, Elizabeth Street, Hobart.
1927	Blake, Frank. Red Chapel Road, Lower Sandy Bay.
1918	Bowling, J. "Barrington," Tower Road, New Town.
1924	Booth, N. P. Messrs. Cadbury-Fry-Pascall Pty. Ltd., Claremont.
1925	Bowerman, Captain. Marine Board, Hobart.
1923	Breaden, J. C. 12 Waverley Avenue, New Town.
1917	Brettingham-Moore, E., M.B., Ch.M. Macquarie Street, Hobart.
1911	Brooks, G. V. Director of Education, Hobart.
1922	Brownell, C. C. 117 Hampden Road, Battery Point.
1907	Brownell, F. L. "Berwyn," Mercer Street, New Town.
1928	Buchanan, Howard. E.S. & A. Bank, Hobart.
1929	Burbury, A. W. Austin's Ferry.
1918	Burbury, Charles. "Brookside," Moonah.
1918	Burbury, Frederick. "Holly Park," Parattah.
1927	Butcher, M. G. 103 York Street, Sandy Bay.
1925	Butler, A. L. Lower Sandy Bay.
1923	Butler, Mrs. G. H. 30 Augusta Road, New Town.
1930	Butler, Dr. T. Macquarie Street, Hobart.

Year of  
Election

- 1930 Butler, Mrs. T. Macquarie Street, Hobart.
- 1909 Butler, W. F. D., B.A., M.Sc., LL.B. Bishop Street,  
New Town.
- 1920 Cane, F. B. 90 High Street, Sandy Bay.
- 1929 Chambers, V. I., LL.B. 22 Murray Street, Hobart.
- 1929 Chapman, G. T. F. 212 Davey Street, Hobart.
- 1930 Chapman, Mrs. Geoffrey. "Ardglen," Holebrook Place,  
Hobart.
- 1928 Chapman, Miss Joi. 212 Davey Street, Hobart.
- 1927 Cherry, P. J. Burnie.
- 1913 Chepmell, C. H. D. Clerk of the Legislative Council,  
Hobart.
- 1920 Clark, W. I., M.B. Macquarie Street, Hobart.
- 1896 Clarke, A. H., M.R.C.S., L.R.C.P. Domain Cottage,  
The Domain, Hobart.
- 1918 Clarke, T. W. H. "Quorn Hall," Campbell Town.
- 1910 Clemes, W. H., B.A., B.Sc. Clemes College, Hobart.
- 1922 Collier, J. D. A. The Librarian, Tasmanian Public  
Library, Hobart.
- 1925 Coogan, W. Lord Street, Sandy Bay, Hobart.
- 1927 Cooper, S. G. 5 Main Road, New Town.
- 1929 Crace-Calvert, W. F. 32 View Street, Hobart.
- 1930 Crane, J. R. 17 Darcy Street, Hobart.
- 1911 Crowther, W. E. L., D.S.O., V.D., M.B. Macquarie  
Street, Hobart.
- 1918 Cummins, W. H., A.I.A.C. Brisbane.
- 1927 Dallas, K. M. 10 Nicholls Street, West Devonport.
- 1924 Davies, G. B. 111 Patrick Street, Hobart.
- 1919 Davies, H. Warlow. 22 Augusta Road, New Town.
- 1908 Dechaineux, L. Principal of the Technical College,  
Hobart.
- 1921 Dryden, M. S. 13 Hillside Crescent, Launceston.
- 1919 Elliott, E. A., M.B., Ch.M. Main Road, New Town.
- 1921 Emmett, E. T. Director of the Tasmanian Govern-  
ment Tourist Bureau, Hobart.
- 1921 Erwin, H. D. Hutchins School, Hobart.
- 1918 Evans, L. Department of Agriculture, Hobart.
- 1921 Eyre, H. Boys' Welfare School, Elizabeth Street,  
Hobart.
- 1902 Finlay, W. A. 11 Secheron Road, Hobart.
- 1918 Fletcher, C. E., M.A. 21 Stoke Street, New Town.
- 1928 Foley, J. C. Weather Bureau, Hobart.
- 1921 Forward, J. R. Public Library, Launceston.
- 1921 Fox, Miss. Ladies' College, Launceston.

Year of  
Election.

- 1930 Fox, Stanley. 17 Montagu Avenue, New Town.  
 1927 Gellibrand, W. T. "Lachlan Vale," Ouse, Tasmania.  
 1927 Giblin, Dr. Arthur. Macquarie Street, Hobart.  
 1922 Giblin, A. V. King Street, Sandy Bay.  
 1908 Giblin, Major L. F., D.S.O., B.A. Ritchie Professor  
 of Economics, the University, Melbourne.  
 1926 Giblin, R. W., F.R.G.S., F.R.C.I. 71 Harrington Gar-  
 dens, London, S.W. 7, England.  
 1921 Giblin, Colonel W. W., C.B., V.D., M.R.C.S., L.R.C.P.  
 Macquarie Street, Hobart.  
 1929 Giles, L. H. 80 Collins Street, Hobart.  
 1927 Gillies, C. L. Department of Agriculture, Hobart.  
 1923 Gorringe, J. A. Kempton, Tasmania.  
 1930 Graham, W. The Grange, Brown's River Road.  
 1927 Grant, H. N. Tasmanian Club, Hobart.  
 1929 Grueber, F. W. 71 Arthur Street, Hobart.  
 1929 Grueber, S. H. 29 Bishop Street, New Town.  
 1928 Gunn, Miss Isabel. Invercarron, Broadmarsh, Tas-  
 mania.  
 1924 Hall, E. L. 38 Lyttleton Street, Launceston.  
 1922 Halligan, G. H., F.G.S. "Uplands," Station Street,  
 Pymble, N.S.W.  
 1918 Harrap, Lieutenant-Colonel G. Launceston.  
 1919 Hay, Rt. Rev. R. S., D.D. Bishop of Tasmania,  
 Bishops court, Hobart.  
 1929 Henderson, Q. J. Mines Department, Hobart.  
 1924 Heritage, F. W. Collins Street, Hobart  
 1921 Heritage, J. E. Frederick Street, Launceston.  
 1921 Heyward, F. J., F.R.V.I.A. 43 Lyttleton Street, Laun-  
 ceston.  
 1915 Hickman, V. V., B.A., B.Sc. Mulgrave Crescent, Laun-  
 ceston.  
 1914 Hitchcock, W. E. Storey's Creek, Avoca, Tasmania.  
 1918 Hogg, G. H., M.D., C.M. 37 Brisbane Street, Laun-  
 ceston.  
 1928 Holland, C. A. 86 Arthur Street, Hobart.  
 1928 Hudson, E. R. Department of Agriculture, Hobart.  
 1923 Hudspeth, W. H. "The Nook," Lower Sandy Bay.  
 1923 Hungerford, Mrs. "Hathaway House," Holebrook  
 Place, Hobart.  
 1909 Hutchison, H. R. 1 Barrack Street, Hobart.  
 1898 Ireland, E. W. J., M.B., C.M. Macquarie Street,  
 Hobart.  
 1919 Jackson, George A. 79 Collins Street, Hobart.

Year of  
Election.

- 1929 Jaques, G. A. Union Bank, Hobart.  
 1906 Johnson, J. A., M.A. Teachers' College, Hobart.  
 1929 Johnson, Norman. Tasmanian Club, Hobart.  
 1922 Johnson, W. R. Clemes College, Hobart.  
 1922 Johnston, J. R. Murray Street, Hobart.  
 1922 Kemp, Andrew. Stoke Street, New Town.  
 1930 Kemp, E. D. F. Earl Street, Sandy Bay.  
 1922 Kennedy, J. 96 Montpelier Road, Hobart.  
 1922 Kennedy, Mrs. J. 96 Montpelier Road, Hobart.  
 1927 King, C. S., M.A. 12 Swanston Street, New Town.  
 1927 Kirby, E. R. 13 Mortyn Avenue, Hobart.  
 1918 Knight, C. E. L., B.Sc. Claremont.  
 1927 Knight, F. C. E. Claremont.  
 1919 Knight, H. W. High Street, Sandy Bay.  
 1918 Knight, J. C. E. Claremont.  
 1924 Legge, R. W. Cullenswood, Tasmania.  
 1919 Lewis, A. N., M.C., LL.D. "Abernant House," Holebrook Place, Hobart.  
 1923 Lewis, Mrs. A. N. "Abernant House," Holebrook Place, Hobart.  
 1887 Lewis, Sir N. E., K.C.M.G., M.A., B.C.L., LL.B. Augusta Road, New Town.  
 1912 Lindon, L. H. "Waimu," Canice Road, Sandy Bay.  
 1926 Lindon, Mrs. L. H. "Waimu," Canice Road, Sandy Bay.  
 1929 Linton, Mrs. E. H. "Meldreth," South Springfield, Tasmania.  
 1912 Lord, Clive E., F.L.S., C.M.Z.S. "Telopea," 5 Quorn Street, Sandy Bay.  
 1927 Lord, Graham H. Vacuum Oil Co., Hobart.  
 1930 Lord, Colonel J. E. C., C.M.G. Derwentwater Avenue, Sandy Bay.  
 1921 Lord, Raymond. Proctor's Road, Queenborough.  
 1924 Lord, Ronald. Derwentwater Avenue, Sandy Bay.  
 1893 McAulay, Professor A., M.A. Lower Sandy Bay.  
 1923 McAulay, Professor A. L., Ph.D. The University, Hobart.  
 1927 Mace, Miss V. E. "The Pottery," Bothwell.  
 1927 Macfarlane, Charles. State High School, Hobart.  
 1923 Macfarlane, Mrs. Charles. 3 Montagu Avenue, New Town.  
 1928 McElroy, J. D. 32 Bellevue Parade, New Town.  
 1930 McIntyre, J. A. L. Wentworth Street, South Hobart.

Year of  
Election.

- 1919 Mackay, A. D. 26 High Street, Launceston.  
 1922 Macleod, Mrs. L. H. 67 High Street, Sandy Bay.  
 1918 Mansell, A. E. Bruny Island.  
 1924 Marsh, James. "Ingomar," Patrick Street, Hobart.  
 1918 Martin, Brigadier-General W. Launceston.  
 1921 Masters, A. H. Forest Road, Trevallyn, Launceston.  
 1929 Mattingley, P. F. C., L.D.D. 36 Brisbane Street,  
 Launceston.  
 1930 Maxwell, C. M. E.S. & A. Bank, Hobart.  
 1926 Meredith, David. Electrolytic Zinc Co., Risdon.  
 1927 Meredith, Mrs. David. 107 High Street, Sandy Bay.  
 1921 Meston, A. L. Ronald Street, Devonport.  
 1909 Millen, Senator J. Roxburgh, Newstead, Launceston.  
 1907 Miller, R. O. M. 6 Main Road, New Town.  
 1930 Mitchell, E. C. "Bayswater," Sandy Bay.  
 1911 Montgomery, R. B. 303 Davey Street, Hobart.  
 1927 Morris, J. M. The Union Bank, Hobart.  
 1928 Morris, Robert J. Liverpool Street, Hobart.  
 1918 Murdoch, Honourable Thomas, M.L.C. 55 Montpelier  
 Road, Hobart.  
 1929 Murray, J. F. N. Federal Taxation Department,  
 Hobart.  
 1926 Murray, L. C. 124 Warwick Street, Hobart.  
 1921 Muschamp, Rev. E. Holy Trinity Rectory, Launceston.  
 1924 Newall, A. P. Charles Street, Moonah.  
 1882 Nicholas, G. C. "Cawood," Ouse, Tasmania.  
 1918 Nicholls, Sir Herbert, K.C.M.G., Chief Justice of Tas-  
 mania. Pillinger Street, Sandy Bay.  
 1910 Nicholls, H. M. Department of Agriculture, Hobart.  
 1921 Nye, P. B., M.Sc., B.M.E. Mines Department, Hobart.  
 1921 Oldham, W. C. 39 George Street, Launceston.  
 1930 Oldmeadow, Mrs. Lloyd. Lyceum Club, Hobart.  
 1924 Oliver, H. Lindisfarne.  
 1927 Orme, K. 76 York Street, Sandy Bay.  
 1921 Overell, Miss Lilian. Holebrook Place, Hobart.  
 1921 Padman, R. S. 56 St. John Street, Launceston.  
 1923 Parker, Dr. G. M. Bellerive.  
 1923 Parker, H. T., M.A. "Montana," Bellerive.  
 1930 Parkes, E. Chief Secretary's Office, Hobart.  
 1921 Patten, W. H. 59 Cameron Street, Launceston.  
 1929 Pearce, Harold. Ellington Road, Lower Sandy Bay.  
 1923 Pedder, A. "Sherborne," Upper Argyle Street, New  
 Town.  
 1927 Penman, C. J. Smelting Works, Launceston.

Year of  
Election.

- 1930 Perkins, Mrs. C. H. 16 Turner Street, Fitzroy Place,  
Hobart.
- 1902 Piesse, E. L., B.Sc., LL.B. "Merridale," Sackville  
Street, Kew, Melbourne.
- 1910 Pillinger, J. 4 Fitzroy Crescent, Hobart.
- 1926 Pitman, Professor E. J. G., B.A., B.Sc. The Univer-  
sity, Hobart.
- 1930 Power, Miss H. 3 Elboden Street, Hobart.
- 1925 Pratt, A. W. Courtney. "Athon," Mount Stuart Road,  
Hobart.
- 1925 Propsting, G. L. Earl Street, Sandy Bay.
- 1927 Raymond-Barker, A. B. Darcy Street, Hobart.
- 1930 Read, Mrs. Ronald. Wellwood Street, Lenah Valley.
- 1929 Read, D. W. The University, Hobart.
- 1921 Reid, A. McIntosh. 270 Davey Street, Hobart.
- 1922 Reid, A. R. Curator, Beaumaris Zoo, Domain, Hobart.
- 1925 Reid, Miss M. L. The University, Hobart.
- 1929 Rex, R. R. 7 Mona Street, Battery Point, Hobart.
- 1921 Reynolds, John. Knocklofty Terrace, Hobart.
- 1928 Richardson, F. B., M.A. 60 Augusta Road, New Town.
- 1925 Robinson, F. G. 42 Regent Street, Sandy Bay.
- 1926 Robson, Mrs. "Elsmore," Richards Avenue, Elphin  
Road, Launceston.
- 1929 Roche, M. M. Mines Department, Hobart.
- 1884 Rodway, L., C.M.G. 77 Federal Street, Hobart.
- 1921 Rolph, W. R. *Examiner and Courier* Office, Launce-  
ston.
- 1913 Ross, Hector. Cambridge, Tasmania.
- 1922 Sargison, H. Elizabeth-street, Hobart.
- 1921 Savigny, J. A.M.P. Chambers, Launceston.
- 1896 Scott, H. H. Curator, Queen Victoria Museum, Laun-  
ceston.
- 1930 Scott, J. B. 5 Greenlands Avenue, Sandy Bay.
- 1928 Scott, R. A. Department of Agriculture, Hobart.
- 1896 Scott, R. G., M.B., Ch.M. 172 Macquarie Street,  
Hobart.
- 1927 Shield, R. J. 122 Collins Street, Hobart.
- 1921 Shields, Honourable Tasman, M.L.C. 13 Paterson  
Street, Launceston.
- 1925 Shoobridge, K. Glenora, Tasmania.
- 1921 Shoobridge, Honourable L. M., M.L.C. "Sunnyside,"  
New Town.
- 1925 Shoobridge, Rupert. "Fenton Forest," Glenora.



Year of  
Election.

- 1923 Shoobridge, S. E. Messrs. Oscar Smith and Co., Macquarie Street, Hobart.
- 1927 Shugg, Dr. Macquarie Street, Hobart.
- 1923 Simson, Mrs. C. J. 3 St. George's Square, Launceston.
- 1929 Slater, R. Kelso, West Tamar.
- 1930 Smith, C. E. 105 Collins Street, Hobart.
- 1927 Smith, Miss Marjorie. C/o *The Countryman*, 4 St. James's Buildings, 123 William Street, Melbourne, C.I.
- 1921 Smithies, F. 34 Paterson Street, Launceston.
- 1925 Stackhouse, C. K. R. 55 Paterson Street, Launceston.
- 1930 Steane, S. W., Conservator of Forests. Forestry Department, Hobart.
- 1928 Steele, R. B., B.Sc. Department of Agriculture, Hobart.
- 1929 Stephens, C. S. The University, Hobart.
- 1927 Sweetnam, H. W., M.B., Ch.B. Macquarie Street, Hobart.
- 1920 Swindells, A. W. C/o Messrs. Murdoch Bros., Market Place, Hobart.
- 1927 Tankard, L. W. Sheffield, Tasmania.
- 1930 Taylor, John. "Winton," Campbell Town.
- 1918 Taylor, W. E. Elboden Street, Hobart.
- 1929 Thirkell, Major R. W., O.B.E., V.D. 405 Elizabeth Street, Hobart.
- 1929 Thomas, A. J. H. 52 Letitia Street, Hobart.
- 1923 Thomas, J. F. Room 8, Wilga Chambers, 159 Phillip Street, Sydney.
- 1922 Thomas, Lieutenant-Colonel L. R., D.S.O. Registrar of the Tasmanian University, Hobart.
- 1921 Thomas, P. H. Department of Agriculture, Hobart.
- 1922 Thompson, E. H. Lower Sandy Bay.
- 1930 Travers, Miss Cecily. Fisher's Avenue, Lower Sandy Bay.
- 1930 Travers, Miss I. "Nateby," Lower Sandy Bay.
- 1928 Tribolet, D. R. 34 Proctor's Road, Hobart.
- 1926 Turner, A. Jefferis, M.D., F.E.S. Wickham Terrace, Brisbane, Queensland.
- 1927 Turner, J. W. Mona Street, Battery Point.
- 1923 Unwin, E. E., M.Sc. Commercial Road, New Town.
- 1930 Walch, Dr. Christine. Macquarie Street, Hobart.
- 1927 Walch, J. H. B., M.B. 71 Crescent Road, West Hobart.
- 1918 Walch, P. B. C. King Street, Sandy Bay.

Year of  
Election.

- 1930 Walker, Alan C., A.R.I.B.A. "Huonden," Macquarie Street, Hobart.
- 1930 Wallace, A. C. 82 Collins Street, Hobart.
- 1928 Walters, Rev. Walter. The Rectory, Scottsdale, Tasmania.
- 1926 Ward, F. E. Director of Agriculture, Hobart.
- 1913 Wardman, John. Superintendent Botanical Gardens, Hobart.
- 1922 Waterworth, E. N. Poet's Road, Hobart.
- 1926 Waugh, Eric C., LL.B. High Street, Sandy Bay.
- 1922 Wayn, Miss A. L. C/o Chief Secretary's Department, Hobart.
- 1930 Webster, E. H. "Greystanes," Red Chapel Avenue, Sandy Bay.
- 1927 Wells, Frank. 16 Montagu Avenue, New Town.
- 1927 Whishaw, R., M.B., Ch.M. Macquarie Street, Hobart.
- 1929 White, G. L. The University, Hobart.
- 1926 Whittle, B. H. Augusta Road, New Town.
- 1925 Winch, M. C/o Brownells Ltd., Hobart.
- 1901 Wise, H. J. Lambert Avenue, Sandy Bay.
- 1930 Young, W. R. "Trenayr," Earl Street, Sandy Bay.

## ANNUAL REPORT

### 1930

#### *The Council and Officers.*

The Annual Meeting was held at the Society's Rooms, The Tasmanian Museum, Hobart, on 24th March, 1930.

The following were elected as members of the Council for 1930:—Dr. A. H. Clarke, Dr. W. E. L. Crowther, Messrs. W. H. Clemes, W. H. Cummins, A. V. Giblin, A. N. Lewis, E. E. Unwin, L. Rodway, F. E. Ward, and Clive Lord (*ex officio*).

Twelve meetings of the Council were held, the attendance being as follows:—Dr. Clarke 3 (leave of absence granted owing to illness, June to December), Dr. Crowther 12, Mr. Lord 12, Mr. Rodway 10, Mr. Clemes 9, Dr. Lewis 9, Mr. Unwin 9, Mr. Ward 6, Mr. Giblin 5, Mr. Cummins (leave of absence granted owing to visit to England) 2.

The Council at its first meeting made the following appointments:—

Chairman of the Council: Dr. A. H. Clarke, M.R.C.S., L.R.C.P.

Secretary: Mr. Clive Lord.

Hon. Treasurer: Mr. A. V. Giblin.

Standing Committee: Messrs. Clemes, Lewis, and Lord.

Trustees of the Tasmanian Museum and Botanical Gardens: Dr. Clarke, Dr. Crowther, Messrs. Lewis, Giblin, Clemes, and Unwin.

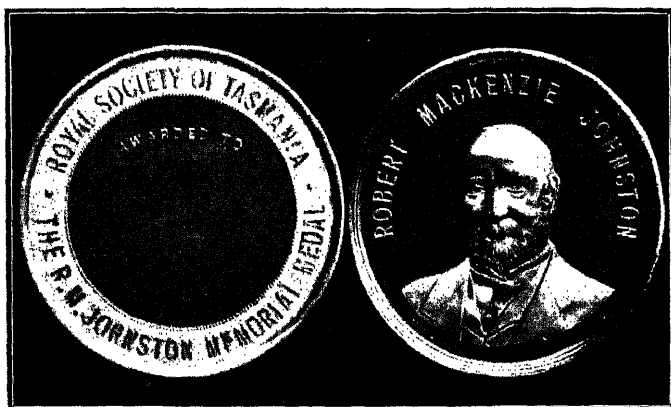
#### *Meetings.*

During the year ten meetings were held and the Council has pleasure in drawing attention to the attendance at the meetings and also to the special interest shown at such meetings as that to celebrate the opening of the new Library and meeting room, the reception to Sir Douglas Mawson, and the scientific staff of the *Discovery*, and the meeting at which Rear-Admiral Evans lectured on Scott's Last Expedition.

In addition to the lectures delivered, the scientific papers submitted were of considerable interest and value.

(See Abstract of Meetings for titles of lectures, papers, &c.)

R. M. JOHNSTON MEMORIAL.



THE R. M. JOHNSTON MEMORIAL MEDAL.

List of Awards:

- 1923 Sir T. Edgeworth David, K.B.E., C.M.G., B.A., F.R.S., F.G.S.
- 1925 Professor F. Wood-Jones, M.B., B.S., M.R.C.S., L.R.C.P., D.Sc.
- 1929 R. J. Tillyard, M.A., Sc.D. (Cantab.), D.Sc., F.R.S., F.N.Z. Inst.,  
F.L.S., &c.



*Library and Meeting Room.*

The Council has pleasure in reporting the removal of the Library to larger premises, and desires to express its thanks and appreciation of the action of the Trustees of the Tasmanian Museum and Art Gallery with regard to the assistance rendered by the Trust in making the removal possible. The Society's meeting room can now accommodate an audience of 350, and it is of interest to note that the room has been twice filled since its opening in September. This fact is of interest as showing the wide appreciation by members of the meetings which were arranged during the past session. Much work yet remains to be done as regards catalogue revision in the new library, but it is hoped that this may be overcome during the coming year. The alterations made considerable work and the Council, in thanking the Trustees of the Museum for their assistance, also desires to add a note of appreciation with regard to the work done by the Museum staff. Had it not been for their working many hours overtime purely in the interests of the Society, the work could not have been carried out with the resources available to the Society. The Council also desires to record its thanks to Miss A. E. Giblin for assistance rendered with regard to the Library cataloguing.

A most welcome addition to the new Library was the presentation made by Mrs. A. N. Lewis. At the first meeting of the Council held in the new quarters, Mrs. Lewis presented a carved blackwood scroll containing the Society's crest. The carving has been incorporated in the panelled blackwood screen behind the President's chair, and the best thanks of the Society are due for this most handsome donation.

Reference to the résumé of meetings and reports will show that the activities of the Society have been well maintained during the session under review, and the removal to larger rooms marks a very distinct advance in the Society's history.

*Finance.*

The question of finance has naturally caused the Council some concern, owing to exceptional expenditure, more particularly with regard to the removal of the Library and the extensions incidental thereto. It is with great regret that the Council has to advise members that the Government has withdrawn from the Estimates the £100 granted as some assistance towards the publishing of the Papers and Proceedings of the Society. Whilst the Council realises fully the need

for economy at the present time, it is felt that the Society has been unduly reduced by the withdrawal of the whole amount of the vote, particularly so when all the advantages arising to the State from the Society's work are taken into consideration. The question of Government support towards publishing the results of Tasmanian scientific work will need to receive the earnest attention of the incoming Council, as without such support it will be a matter of considerable difficulty to issue the Papers and Proceedings in the usual form. The matter is further complicated owing to the exceptional expenditure during the year, mainly in connection with the removal of the Library; no payments have been made on account of the 1930 Papers and Proceedings, and a large amount is outstanding. It was hoped to meet this out of the £100 Government Grant usually paid over in January, but owing to the withdrawal of the vote the Society is thrown entirely on its own resources.

#### *Papers and Proceedings.*

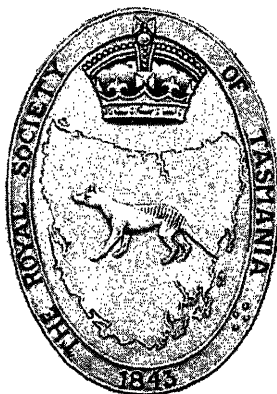
The papers read before the Society were of a high standard, and those printed in the Proceedings should prove of considerable interest. Several papers were held over and every effort will be made, in the interests of Tasmanian scientific research, to publish the results of such research work during the coming year, but, owing to financial considerations, the matter is one of considerable difficulty. The support of the members and also of all who appreciate the value of scientific research to Tasmania is hoped for in this connection, as the work which is being so ably done by research workers is in the public interest.

#### *Branches and Sections.*

The Northern Branch and the several sections of the Society have continued their activities during the period under review. Detailed Reports of these activities are omitted on account of economy.

#### *Obituary.*

It is with regret that the Society has to report the deaths of the following members:—Sir Alfred Ashbolt, Mr. J. W. Beattie, Mr. Charles Davis, Dr. A. Withers Green, Captain F. W. Hood, Mr. J. G. Mitchell, Mr. M. W. Simmons, Colonel R. P. Smith.



THE ROYAL SOCIETY OF TASMANIA MEDAL.

List of Awards:

- 1927 L. Rodway, C.M.G.  
1930 Clive Lord.

Note.—The Royal Society of Tasmania Medal was established in 1927. It is awarded for eminence in research and for work of outstanding merit on behalf of the Society and the State (*vide* Abstract of Proceedings, P. & P., 1927, pp. 213-214).





# THE ROYAL SOCIETY OF TASMANIA.

## GENERAL FUND.

### STATEMENT OF RECEIPTS AND EXPENDITURE, 1930.

RECEIPTS.			EXPENDITURE.		
	£	s. d.		£	s. d.
Balance brought forward .. .. .	0	9 7	Salaries, Travelling Expenses, etc. .... .	56	0 0
Subscriptions .. .. .	242	11 0	Papers and Proceedings—		
Government Grant .. .. .	100	0 0	1929 (Part) .. .. .	112	19 6
Rent .. .. .	5	10 0	1930 (Nil) .. .. .	—	—
Sale of Publications .. .. .	1	6 3	General Printing .. .. .	112	19 6
Miscellaneous .. .. .	9	14 0	Library .. .. .	33	8 2
			Insurance .. .. .	29	14 3
			Light and Fuel .. .. .	5	18 9
			Petty Cash and Postages ..	3	10 0
			Lantern, Operator, etc. ....	13	0 0
			Miscellaneous, including cost of Special Meetings, Re-opening Library, etc. ....	15	10 0
			Northern Branch .. .. .	68	14 9
			Refund to M.A.M. Fund ..	8	8 0
			Bank Charges .. .. .	1	0 0
			Balance carried forward ..	0	0 10
				11	6 7
				<u>£359</u>	<u>10 10</u>

Examined and certified to be correct.

WALTER E. TAYLOR, F.F.I.A.,

3rd March, 1931.

Hon. Auditor.

A. V. GIBLIN, Hon. Treasurer.

CLIVE E. LORD, Secretary.

8th January, 1931.

**THE ROYAL SOCIETY OF TASMANIA.**  
**R. M. JOHNSTON MEMORIAL FUND, 1930.**

RECEIPTS.		EXPENDITURE.	
	£ s. d.		£ s. d.
Balance brought forward . . . . .	2 18 6	Books purchased for Library (Encyclo-	
Interest . . . . .	14 12 0	pædia Britannica, 14th Ed.) . . . . .	31 4 0
Dr. Balance carried forward . . . . .	13 13 6		
	£31 4 0		£31 4 0

Examined and certified to be correct.  
WALTER E. TAYLOR, F.F.I.A.,  
3rd March, 1931. Hon. Auditor.

A. V. GIBLIN, Hon. Treasurer.  
CLIVE E. LORD, Secretary.  
8th January, 1931.

**MORTON ALLPORT MEMORIAL FUND, 1930.**

RECEIPTS.		EXPENDITURE.	
	£ s. d.		£ s. d.
Balance brought forward . . . . .	4 10 6	Books purchased for Library . . . . .	14 13 5
Interest . . . . .	10 4 0	Credit Balance carried forward . . . . .	1 1 1
Refund from General Account . . . . .	1 0 0		
	£15 14 6		£15 14 6

Examined and certified to be correct.  
WALTER E. TAYLOR, F.F.I.A.,  
3rd March, 1931. Hon. Auditor.

A. V. GIBLIN, Hon. Treasurer.  
CLIVE E. LORD, Secretary.  
8th January, 1931.

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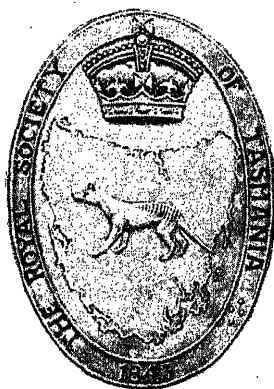
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PAPERS & PROCEEDINGS  
OF  
THE ROYAL SOCIETY  
OF TASMANIA

FOR THE YEAR

1931



(With 19 Plates and 20 Text Figures)

ISSUED 25th JULY, 1932

PUBLISHED BY THE SOCIETY

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1932

*Price : Ten Shillings*

The responsibility of the statements and opinions in the following papers and discussions rests with the individual authors and speakers; the Society merely places them on record.

# THE ROYAL SOCIETY OF TASMANIA

## PAPERS AND PROCEEDINGS, 1931.

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# THE ROYAL SOCIETY OF TASMANIA

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The Royal Society of Tasmania was founded on the 14th October, 1843, by His Excellency Sir John Eardley Eardley Wilmot, Lieutenant Governor of Van Diemen's Land, as "The Botanical and Horticultural Society of Van Diemen's Land." The Botanical Gardens in the Queen's Domain, near Hobart, were shortly afterwards placed under its management, and a grant of £400 a year towards their maintenance was made by the Government. In 1844, His Excellency announced to the Society that Her Majesty the Queen had signified her consent to become its patron; and that its designation should thenceforward be "The Royal Society of Van Diemen's Land for Horticulture, Botany, and the Advancement of Science."

In 1848 the Society established the Tasmanian Museum; and in 1849 it commenced the publication of its "Papers and Proceedings."

In 1854 the Legislative Council of Tasmania by "The Royal Society Act" made provision for vesting the property of the Society in trustees, and for other matters connected with the management of its affairs.

In 1855 the name of the Colony was changed to Tasmania, and the Society then became "The Royal Society of Tasmania for Horticulture, Botany, and the Advancement of Science."

In 1860 a piece of ground at the corner of Argyle and Macquarie streets, Hobart, was given by the Crown to the Society as a site for a Museum, and a grant of £3,000 was made for the erection of a building. The Society contributed £1,800 towards the cost, and the new Museum was finished in 1862.

In 1885 the Society gave back to the Crown the Botanical Gardens and the Museum, which, with the collections of the Museum, were vested in a body of trustees, of whom six are chosen from the Society. In consideration of the services it had rendered in the promotion of science, and in the formation and management of the Museum and Gardens, the right was reserved to the Society to have exclusive possession of sufficient and convenient rooms in the Museum, for the safe custody of its Library, and for its meetings, and for all other purposes connected with it.

In 1911 the Parliament of Tasmania, by "The Royal Society Act, 1911," created the Society a body corporate by the name of "The Royal Society of Tasmania," with perpetual succession.

The object of the Society is declared by its Rules to be "the advancement of knowledge."

His Majesty the King is Patron of the Society; and His Excellency the Governor of Tasmania is President.

**PAPERS**  
**OF**  
**THE ROYAL SOCIETY OF TASMANIA**  
**1931**

---

**TASMANIAN COLLEMBOLA OF THE FAMILY**  
**SMINTHURIDÆ.**

**(GLOBULAR SPRINGTAILS)**

By

**H. WOMERSLEY, A.L.S., F.E.S.**

Entomologist, Section of Pasture and Field Pests, Division  
of Economic Entomology, Council for Scientific and Industrial  
Research.

Plate I. and Six Text-figures.

(Read 13th July, 1931)

The Collembola, or Springtails, are one of the lesser known orders of the Insecta, differing from all others in possessing not more than six abdominal segments and in having in most species a peculiar forked spring by which they are able to leap with great agility.

They are a very primitive group of insects, entirely apterous, and have recently been shown to be the earliest fossil insects.

The Collembola have been divided by Börner into two suborders, (1) the ARTHROPLEONA, comprising the more elongate forms in which the segmentation of the thorax and abdomen is well defined, and (2) the SYMPHYPLEONA or globular forms with little or no segmentation.

The latter suborder contains two families, the NEELIDÆ, a group of peculiar insects with antennæ much shorter than the head and inserted low down on the face, and the SMINTHURIDÆ, with antennæ longer than the head and situated well up towards the vertex.

To this latter family belong most of the Collembola which are of serious economic importance. Owing to the immense numbers in which they usually occur the amount of damage caused to clover and other crops is often of very serious importance.

During the past twelve months I have received from Dr. R. J. Tillyard, Chief of the Division of Economic Entomology of the Australian Commonwealth Council for Scientific and Industrial Research, several collections of SMINTHURIDÆ made by himself, Mr. H. M. Nicholls, Microbiologist, Department of Agriculture, Hobart, and Mr. R. A. Scott, Agonomist, Department of Agriculture, Launceston, in various parts of Tasmania.

These collections proved to be of the greatest interest, and I desire to record my thanks to the collectors for the opportunity of studying the contents. Altogether, seven species were obtained, of which two are new to science, while of the remainder four are new to Australia. These four, together with the previously known and abundant *Sminthurus viridis*, Lin., have possibly been introduced from Europe. It is important to notice that, as in the case of the two new forms, which are probably indigenous to the continent, they may under suitable conditions become a pest.

Of the morphological characters used in the identification of these insects the furca or spring is one of the most important. This organ is attached to the fourth or fifth abdominal segment. It consists of a basal piece, the *manubrium*, from which arise two arms, the *dentes*, each of which carries a terminal piece called the *macro*. When the insect is in repose the spring is folded under the body, being held by a catch. Ventrally from the first abdominal segment arises an organ termed the *ventral tube*. From the basal portion of this two long filaments can be extruded at will. These may or may not have wart-like tubercles on the walls.

The feet exhibit many features of specific and generic value. Normally there are two claws, an upper or larger and a lower or smaller. The lower claw is sometimes regarded as an *empodial appendage* and may be wanting. The upper has the inner edge sometimes toothed or plain, and in some cases the claw is enclosed in a sheath or *tunica*. The lower claw may have both an inner and an outer lamella, and in most species of this family there arises apically or subapically a fine bristle. On the tibiotarsus just above the claw may be a number, usually three or four, of long clavate bristles.

The eyes when present consist of from one to eight simple ocelli on each side usually on a patch of black pigment.

The antennæ in the SMINTHURIDÆ are four jointed, although the apical joint is often secondarily divided.

*Key to the Genera of SMINTHURIDÆ.*

I. Ventral tube with smooth walls.

Subfam. SMINTHURIDÆ C.B.

- (a) Abdom. V. & VI. fused. Filaments of ventral tube shorter than basal part. Male antennæ morphologically different from that of female. Female without genital appendages.

Tribe SMINTHURIDINI C.B.

Genus *Sminthurides* C.B.

- (b) Abdom. V. & VI. distinctly differentiated. Filaments of ventral tube long. Antennæ alike in both sexes. Female with genital appendages.

Tribe KATIANNINI C.B.

1. Ant. IV. not subdivided. Genus *Sminthurinus* C.B.

Ant. IV. distinctly subdivided. 2.

2. Ant. III. normal. Genus *Arrhopalites* C.B.

Ant. III. with a peculiar outer peg-like organ; long and strong setæ on ant. I., II., and III., some of which lie flat. Strong spines also above and between eyes. Mucrones with three unequal lamellæ.

Genus *Katianna* C.B.

II. Ventral tube with warted walls.

- A. Antennæ bent between joints II. and III., IV. shorter than III.

Subfam. DICYRTOMINÆ C.B.

1. Upper claw without tunica. 2.

Upper claw with tunica. Dentes without serrated setæ. Ant. III. and IV. not subdivided.

Genus *Dicyrtomina* C.B.

2. Ant. III. and IV. not subdivided, at most with slight indications of ringings. Dentes with or without serrated setæ.

Genus *Dicyrtoma* Bourl., C.B.

Ant. III. and IV. or only IV. (distally) distinctly subdivided. Dentes with serrated setæ.

Genus *Ptenothrix* C.B.

- B. Antennæ bent between III. and IV., IV. longer than III.

Subfam. SMINTHURINÆ C.B.

- (a) Tibiotarsus with 2-3 short adjacent clavate hairs.  
Upper claw without tunica.

Tribe BOURLETIELLINI C.B.

1. Hind tibiotarsus with an inner series of 5-6 spines close together which may be serrated or not. These are termed by Börner "Rastraldornen."

Genus *Rastriopes* C.B.

Hind tibiotarsus without the above. 2.

2. With an abnormal protuberance, single or double, in the middle of the dorsum. Lower claw replaced by a modified clavate hair.

Genus *Corynephoria* Absolon.

Without the above dorsal protuberance. With or without a lower claw. 3.

3. Genital segments alike in both sexes.

Genus *Deuterosminthurus* C.B., Linnan.

Genital segments of male with a clasping organ of hooks and curved bristles.

Genus *Bourletiella* Banks.

- (b) Tibiotarsus without adjacent clavate hairs, or, if present, then outstanding. Upper claw with or without tunica.

Tribe SMINTHURINI C.B.

1. Ant. III. in proximal half with four strong bristles, stronger than the rest and in the form of a square. Also a fifth short bristle. 2. Ant. III. with three characteristic bristles but not stronger than the rest. Mucronal bristle absent. Claw with a distinct tunica. Tibiotarsus without clavate hairs.

Genus *Sphyrotheca* C.B.

2. Furcal segment dorsally with two roundish glandular papillæ. Mucronal bristle present. Claw with distinct outstanding tunica.

Genus *Allacma* C.B.

Furcal segment without papillæ. Mucronal bristle present or absent.

Genus *Sminthurus* (Linn.), Lubbock.

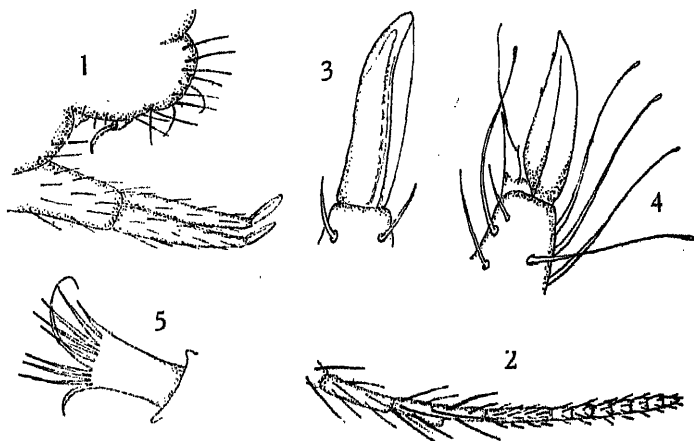
*Description of the known Tasmanian species of SMINTHURIDÆ*

## Genus KATIANNA C.B.

## KATIANNA AUSTRALIS n. sp.

(Plate I., fig. 1. Text-fig. I., 1-5.)

This species is closely allied to the type of the genus, *K. cobold*, described by C. Börner from S. America. From *K. oceanica*, the only other Australian species, which was described by Schött from North Queensland, it differs in colour and markings, in the ratio of antennal segments, in the number of clavate hairs on the tibiotarsus, and in the structure of the claws.



Text-fig. I.: *Katianna australis* n. sp. 1, Anal segments and furca of female, showing genital appendage. 2, Antenna. 3, Mucro from side. 4, Tip of tibiotarsus, side view. 5, Female genital appendage from above.

From the specimens sent to me, this species appears to occur only in the Stanley Area of Tasmania.\*

Diagnosis: Length 1.75 mm. Colour yellowish with heavy dark mottling on dorsum and extending down the sides. Anal segments rather more yellow. Head and face with a dark patch between the antennal bases and another below extending to the mouth. Eye patches black. Antennæ dark

\*Since recorded as widespread on the mainland of Australia; hence the specific name.

blackish green, basal joints a little lighter. Venter, legs, and furca yellowish.

Eyes eight on each side on black patches, behind and between which are a number of strong curved spine-like setæ. Antennæ twice as long as head, diagonal, joints relatively  $1 : 2\frac{1}{2} : 2\frac{1}{2} : 5\frac{1}{2}$ ; last joint with 4-5 secondary divisions in distal half. Ant. III. with an outer peg-like organ at the middle. Ant. I., II., and III. with particularly long and strong setæ, the longest of which are half the length of joint and lie flat. Ant. IV. with the usual whorls of fine hairs.

Legs: Tibiotarsus with 4-5 clavate hairs. Upper claw strong, almost as long as the mucro, with two inner teeth, one just beyond the middle, the other near the tip. Lower claw about half the length of upper, with broad inner lamella and long subapical seta which reaches the tip of upper claw, inner angle with two fine teeth. Claws similar on all feet.

Furca comparatively short. Manubrium : dentes : mucro =  $1 : 2 : \frac{1}{2}$ . Mucro with unequal lamellæ as in *Bourletiella*, the inner lamella with coarse flat teeth.

Genital appendages of female strongly branched.

Tenaculum with curved basal piece, at tip of which are two setæ, rami with three barbs.

Clothing of numerous strongly curved setæ.

#### Genus DEUTEROSMINTHURUS C.B.

#### DEUTEROSMINTHURUS BICINCTUS Koch,

form REPANDUS Agren.

(Plate I., fig. 2.)

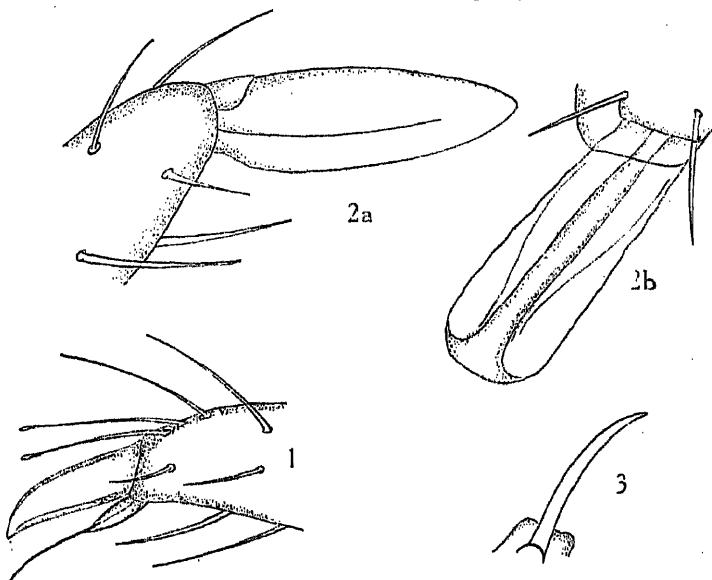
This small species was represented in the collections only by specimens from Glenorchy, Tasmania. It is a curious saddle-shaped insect, and on this account easily recognised.

It measures barely 1 mm. in length and varies very much in colour. The type form of the species is yellow with two broad blackish-brown cross bands. In *repanda* it is entirely yellow, tending to orange on the dorsum. The type as well as the entirely black form *pallipes* Lubbock, may be expected to occur in Australia. They are all common clover insects in Europe.

DEUTEROSMINTHURUS CINQUEFASCIATUS Kraus-  
bauer.

(Plate I., fig. 3. Text-fig. II., 1-3.)

This is a rather larger species which is very distinctive on account of the white cross bands. In Tasmania it appears to be already known as the "Banded Springtail." All the



Text-fig. II.:—*Deuterosminthurus 5-fasciatus* Krbr. 1, Tip of tibiotalpus from side. 2, Macro (a) from side, (b) above. 3, Female genital appendage.

specimens of this species, except a solitary one from Gawler, were from the Forth Area.

It is perhaps with some doubt that these specimens are referred to this species, which has only been recorded from the original locality at Weilburg a.d. Lahn in Germany by Krausbauer in 1898. It does not appear to have been observed since, but the somewhat brief account agrees in details with the Tasmanian material.

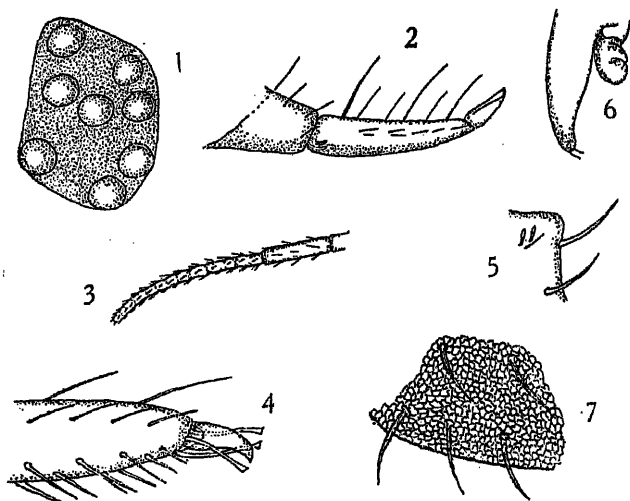
DEUTEROSMINTHURUS OBSCURUS n. sp.

(Plate I., fig. 4. Text-fig. III., 1-7.)

Four specimens of this new species were taken attacking the tops of young carrots at Scottsdale, Tasmania, 3/12/26.



It is a dark form in which the pigmentation is carried on to the furca and legs. In outward appearance it somewhat resembles *D. bicinctus* f. *pallipes* Lubbock. From other Tasmanian species of the genus it is easily separated by the absence of the lower claw.



Text-fig. III. :—*Deuteromminthurus obscurus* n. sp. 1, Ocelli and eye patch. 2, Furca. 3, Antenna. 4, Tip of tibiotarsus. 5, Antennal III. organ. 6, Tenaculum. 7, Dorsal cuticle and setae.

Diagnosis: Size 1.3 mm. Colour entirely black except for the vertex of the head, antennæ, legs, and furca which are only a shade lighter, still retaining a deep pigmentation.

Eyes eight on each side. Head : ant. I. : II. : III. : IV. = 17 : 2½ : 5 : 5 : 13; ant. IV. with 16-20 secondary rings and with a minute terminal knob. Ant. III. organ as in fig. III., 5.

Legs normal. Claws alike on all feet, without inner or outer teeth, one-third the length of mucro. Lower claw wanting. Clavate tibiotarsal hairs 3-8-2, broadly spatulate at tips.

Body hairs long, finely ciliated and numerous. A pair of sensory setæ (bothriotrichia) are present on each side of the anal segment, and there are three others in a diagonal line on each side of the abdomen. The cuticle is strongly granular. Female genital appendages?

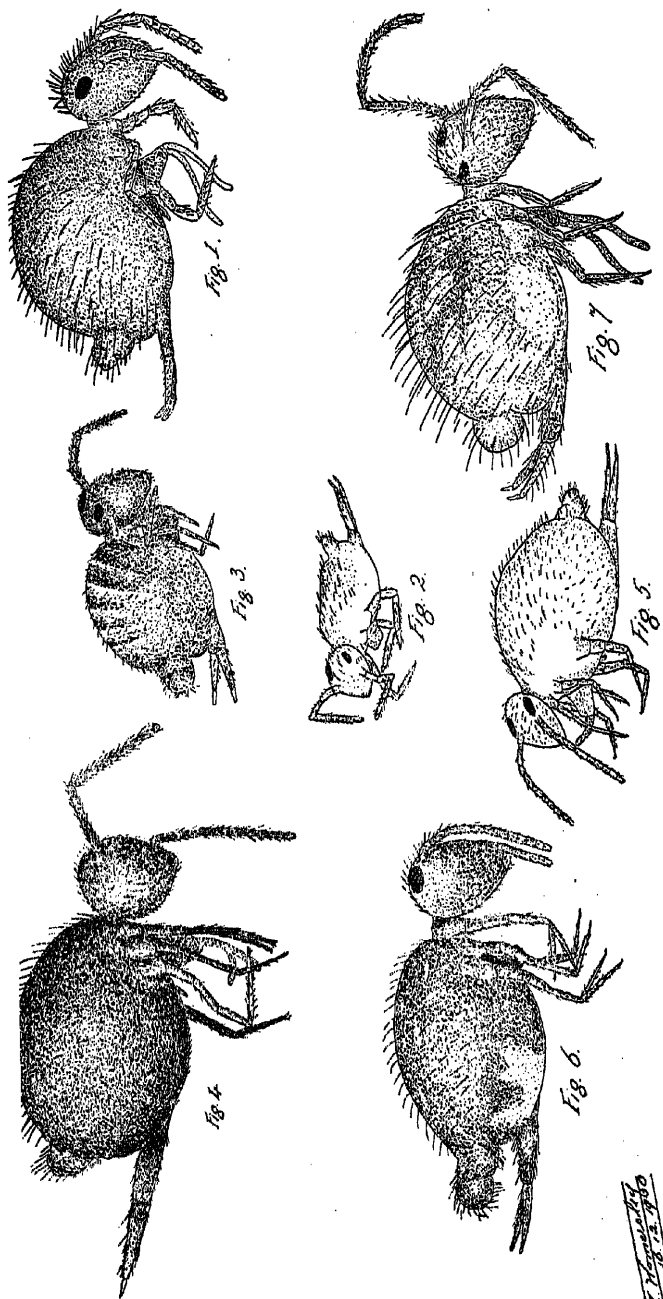


Fig. 1. *Kaitiana australis* n. sp. Lateral view.  
 Fig. 2. *Deuteroemithurus bicinctus* f. *repandus* Arren. Lateral view.  
 Fig. 3. *Deuteroemithurus cinquefasciatus* Krausbr. Lateral view.  
 Fig. 4. *Deuteroemithurus obscurus* n. sp. Lateral view.  
 Fig. 5. *Bouriciella arvalis* Fitch. Lateral view.  
 Fig. 6. *Bouriciella hortensis* Fitch. Lateral view.  
 Fig. 7. *Sminthurus viridis* (Linn.) Lubb. Lateral view.

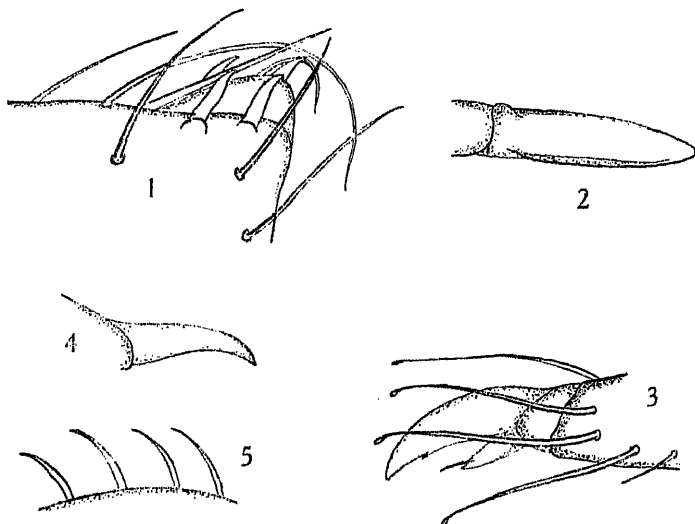
G. H. S. 12. 1900  
 12. 1900



Genus *BOURLETIELLA* Banks.*BOURLETIELLA ARVALIS* Fitch.1863. Syn. *B. lutea* (Lubb.) Agren. (1867) 1903.

(Plate I., fig. 5. Text-fig. IV., 1-5.)

This is a very common species of clover springtail throughout Europe. Together with the next species it has been recorded from England and America as damaging young root crops, causing the effect known as "strangle neck."



Text-fig. IV. 1.—*Bourletiella arvalis* Fitch. 1, Spines on anal segment of male. 2, Mucro from side. 3, Tip of tibiotarsus. 4, Female genital appendage from side. 5, Dorsal setae.

It has only recently been shown by Dr. Folsom (*A List of the Insects of New York State*, Cornell Univ. Agric. Exper. Sta., Mem. 101, 1928) that this species, which has previously been known as *B. lutea* Lubbock, is synonymous with *B. arvalis* Fitch.

While differing in its lighter colouring from the following species it can be definitely separated in the male sex by the form of the clasp ing organ on the anal segments, and in the female by the form of the genital appendages (see text figures).

In Tasmania it occurs in the Stanley, Franklin, Longford, Forth, Gawler, and Forest Areas.

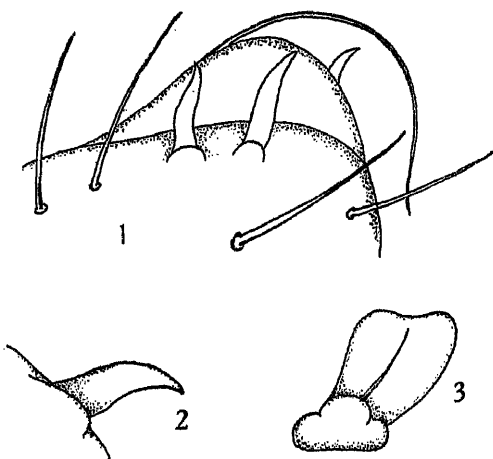
## BOURLETIELLA HORTENSIS (Fitch) Folsom.

Syn. *pruinosa* C.B.

(Plate I., fig. 6. Text-fig. V., 1-3.)

This species has been considered by some authors as only a dark form of the preceding, but, as stated above, it differs very markedly in the secondary sexual characters. It occurs on root crops in America and Europe, and has also been recorded from Japan.

In Tasmania it has been taken in the Forth, Gawler, and Stanley Areas.



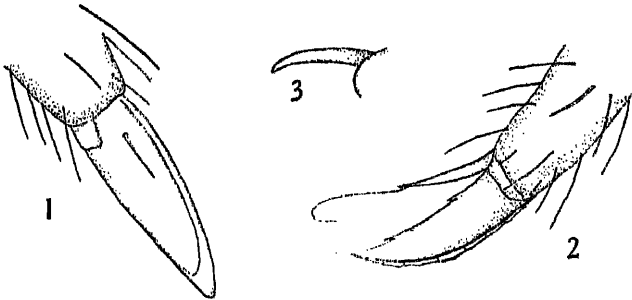
Text-fig. V.:—*Bourletiella hortensis* Fitch. 1, Spines on anal segments of male. 2, Female genital appendage from side. 3, Female genital appendage from above.

Genus SMINTHURUS (Linn.) Lubbock.

SMINTHURUS VIRIDIS (Linn.) Lubb.

(Plate I., fig. 7. Text-fig. VI., 1-3.)

This is the common Clover Springtail or Lucerne Flea, and everywhere appears to be the dominant springtail of grass and clover land. In Tasmania it is much more abundant than in Europe, as also where it occurs in other parts of Australia.



Text-fig. VI.: *Sminthurus viridis* Linn. 1, Mucro from side. 2, Tip of tibiotalrus. 3, Female genital appendage from side.

It is a species much given to colour variation, and many forms have been given varietal names. It can be definitely identified microscopically by the lack of clavate tibiotalrusal hairs, the strong mucronal bristle, and the distinct beaded tunica on the upper claw.

# ABORIGINAL ROCK-CARVINGS ON THE NORTH-WEST COAST OF TASMANIA.

By

A. L. MESTON, M.A.

Plates II.-VIII.

(Read 13th July, 1931.)

Many descriptions have been given of aboriginal art in various parts of Australia, but accounts of the skill of the Tasmanians in drawing and carving have been extremely meagre. In recent years, however, a number of rock carvings have been discovered in one locality on the North-West Coast, and it is the purpose of this paper to describe them. Before doing this, I intend briefly to review all previous descriptions of the art of the Tasmanian aborigines.

Péron, who visited Tasmania in 1802 as naturalist on the *Géographe*, gave us the first account of aboriginal drawings. On the under surface of some of the best and largest pieces of bark covering a burial mound discovered by him at Oyster Bay, he found "some characters crudely marked, "similar to those which the aborigines tattooed on their "forearms."

In 1857 Daniel Bunce, describing his journey through Middlesex Plains, the Vale of Belvoir, and over the Black Range, makes a reference to aboriginal drawings. "Some "time previously," he writes, "two carts belonging to the "V.D.L. Co. had passed over this ridge each drawn by six "oxen with their drivers. It appears that some natives had "observed this, and a short time afterwards, one of the "Company's servants passing that way, found in one of their "rudely constructed huts, a piece of the bark of a tree with "a rough drawing of the whole scene. The wheels of the "carts, the bullocks drawing them, and the drivers with their "whips over their shoulders were all distinctly depicted in "their rude but interesting manner." This is obviously a reference to the taking of two carts to the Surrey Hills in 1828 by the V.D.L. Co., the first occasion that wheeled vehicles had ever passed that way.

Bonwick says that Mr. G. A. Robinson saw drawings of men and women with some curious hieroglyphics, like the totems of tribes, when he was on the West Coast in 1831. He also mentions "the red hand marked on trees and rocks

"alike in Tasmania and Australia," and gives "some rude sketches of men and animals with five drawings as seen by Mr. Commissary Browne on a tree representing the sun, the moon, some snakes, and five persons in a boat."

Dr. Ross relates the discovery of "some rude drawings of human figures, of squares and circles scratched on the inner side of the bark of a hut in the valley of the Ouse."

Calder writes of some huts and "on the bark that covered them, were some extraordinary charcoal drawings: one representing two men spearing an animal, which from its erect position was I presume meant for a kangaroo: though the artist, by a strange oversight, had forgotten the animal's tail and had made the forelegs about twice as long as the hinder ones. There was also an outline of a dog, and an emu, really not badly done; and some other designs the exact meaning of which I was not able to make out." Elsewhere he states: "But the chef-d'œuvre was a battle piece—a native fight—men dying and flying all over it."

All of these Ling Roth mentions, but there is another reference which escaped his notice. In February, 1827, Henry Hellyer, architect and surveyor of the V.D.L. Co., came upon two native huts in the Surrey Hills. "In one of the huts," he writes, "I saw a drawing of the moon done with charcoal, upon the inside of one of the slabs of bark which formed the hut: and regarding it as an evidence of there being artists among them I cut out the piece, and placed it carefully between two pieces of bark in my knapsack." He does not say why he thought the drawing was a representation of the moon, but I imagine it was crescent shaped and left little doubt as to its meaning.

Such then has been the extent of our knowledge of the artistic efforts of the Tasmanian aborigines, so scanty that Ling Roth goes so far as to say, "The whole question of the existence of drawings by aborigines before European advent is practically an open one for the evidence is not satisfactory." "It should be mentioned," he continues, "that Milligan in his vocabulary gives *Depict*—draw in charcoal: '*macoolana*.' This at first sight seems conclusive. But in the same vocabulary, he gives other words for objects not known to the natives in their wild state—e.g., '*bread*,' '*spaniel*,' '*gun*,' and '*gunpowder*.'"

Before discussing the carvings themselves it will be well to describe their situation. Where the Mersey runs into Bass Strait the western shore is prolonged into a rocky headland, known as the Bluff. This promontory, very low



where it joins the mainland, extends seawards for 633 yards, and runs up to a height of 74 feet. The remains of a fairly extensive midden in the south-west corner give ample evidence of aboriginal occupation. Until quite recent years the place remained very much as it was when the native aborigines frequented it. A sandbank covered with booby-allas afforded shelter from all winds, and behind it lay a little fresh water lagoon fringed with tea trees, while in front a bank of shingle provided ample material for their stone implements. The lagoon is now filled in, the tea trees have been cut down, and the sandbank is in part removed, leaving little of the original charm.

While it is impossible to say definitely what the carvings represent, they seem to fall into two classes, one depicting natural objects, the other signs and patterns. And, moreover, it is impossible to say whether what appears to us as a sign or pattern may not be a conventionalised drawing of some object well known to the aboriginal. The natural objects are a fish, a snake, a bird's head, a leaf, and a *haliotis* shell. The signs and patterns include circles, concentric circles, large ovals with smaller ovals set within, and ovals each with a salient which bears a striking likeness to a specialised type of aboriginal stone scraper. Occasionally, the artist has made use of a natural unevenness in the rock to make his design stand out the more, but cracks in the rock have not been used. In every design I have examined the natural cracks are transverse to the carvings. This is particularly noticeable in plate IV., figure 2, and plate VII., figure 2.

The rock of which the Bluff is composed is diabase, and it is in this hard, refractory material that the engravings are made. All are cut on horizontal faces of rock and are distributed over the whole area of the promontory. But although I have made a careful search of the north coast from West Head to Circular Head I have found none elsewhere. The number of carvings known to me is seventy-five, but there is ample evidence from remnants that at one time the number was much greater. The condition of those extant varies greatly. Some are little more than mere lines, while others are deeply incised. On the seaward face of the headland, swept by spray every storm, weathering is rapidly destroying them, and since I first saw them in February, 1929, five have, by the flaking of the rock surface, completely disappeared. Several others will disappear this winter. The effects of weathering are well shown in plate III., figure 1, and plate IV., figure 1.

A remarkable feature is the depth of some of the carvings in such hard material. In this respect they are in striking contrast with carvings found on the mainland of Australia, which are for the greater part cut in soft limestone, slate, or sandstone, and are not very deep. Of those found on the Bluff, the deepest, the *haliotis* shell, is 58 millimetres, another reaches a depth of 26 millimetres, another 22, another 21, another 18, two others 17, three others 16, and another 15 millimetres. The great depth combined with a comparatively narrow width is a remarkable feature of many of the carvings. What tools the makers of these figures used is a puzzle. A very careful search, however, has failed to reveal any tools of the workers; but they would seem to have been made, not by rubbing, but by a pointed piece of quartzite, breccia, or similar hard material driven by a stone used as a hammer.

That the carvings exist at the Bluff, and, to the best of our knowledge, nowhere else, is remarkable, but a possible explanation is that either this area was sacred, or was a place of assembly and consultation. For either purpose it is admirably adapted. Calder describes a meeting place and a ceremonial tree west of the Tamar, only some thirty miles away, and it seems that the Bluff was in some way of grave importance to the aborigines.

In getting photographs the chief difficulty was to prevent distortion, but this was overcome by using an optipod which enabled the camera to be focused from directly above the figures. Several when first seen were encrusted with lichens, which it was necessary to clear away with a brush.

The important question of the cause of the carvings remains to be discussed. It is generally recognised that art for art's sake is not known to primitive peoples. All art was utilitarian, and took its rise from a belief in magic. This is true of the prehistoric paintings of the caves of Altamira, of the drawings and sculptures in the caverns of the Cantabrian Pyrenees, of the Haute Garonne, and of the Dordogne. It is true of the natives of North-West Australia. All the pictures made by the Worrora tribe except those of the human being represent some article of food, and even those of the human being "the Wonjuna" are made to ensure that rain will not fail. "The belief is," writes Mr. J. R. Love, "that wherever the picture of an object of food is preserved in a picture cave, there that object will continue to flourish and increase. An object that recurs not infrequently, and that appears meaningless, till explained, is the liver of a sting-

"ray, a favourite article of food. When explained as the "liver it is seen to be quite a fair picture of a liver. So also "with some of the edible roots. But quite a number of the "pictures are conventional representations of some article of "food, or some part of the body, which do not to the European eye bear any resemblance to the object represented." If this material outlook is true of so many primitive races it is fair to suppose it true of our aborigines. To them art was not a means of self-expression, but a weapon to encounter and overcome the Great Unknown.

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Fig. 1. View of Bluff from the air.

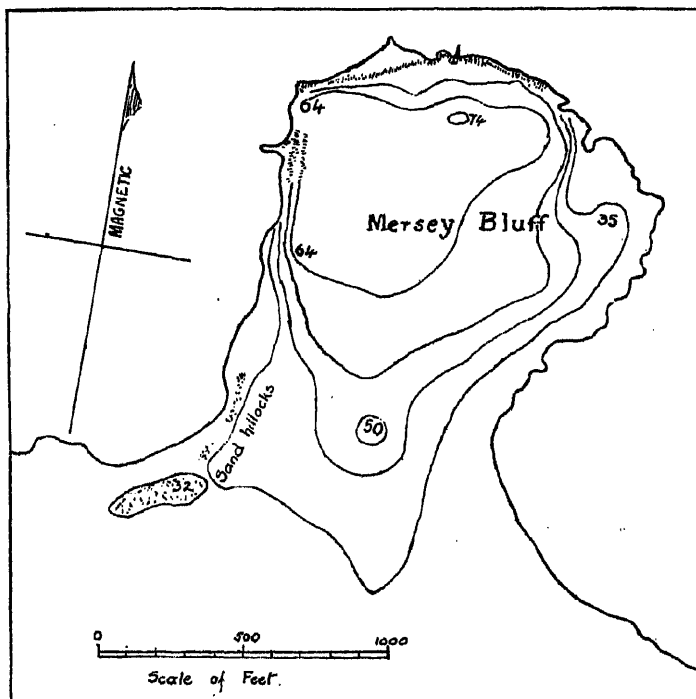


Fig. 2. Contour Map of Bluff.



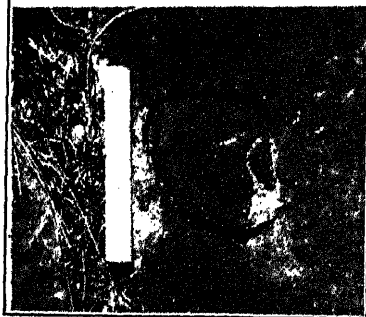


Fig. 1.

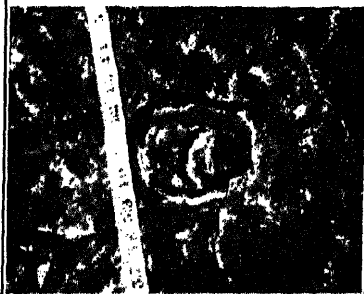


Fig. 2.



Fig. 3.

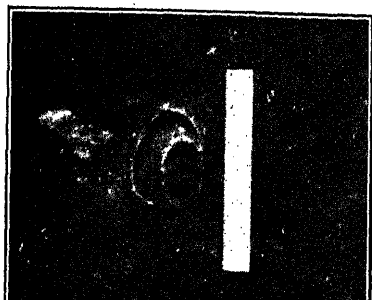


Fig. 4.

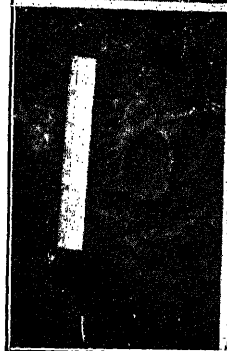






Fig. 1.



Fig. 2.

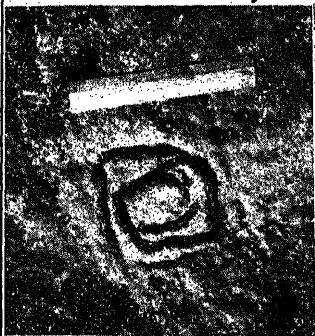


Fig. 3.



Fig. 4.

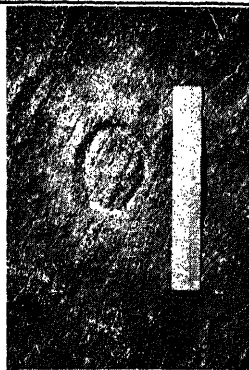


Fig. 5.



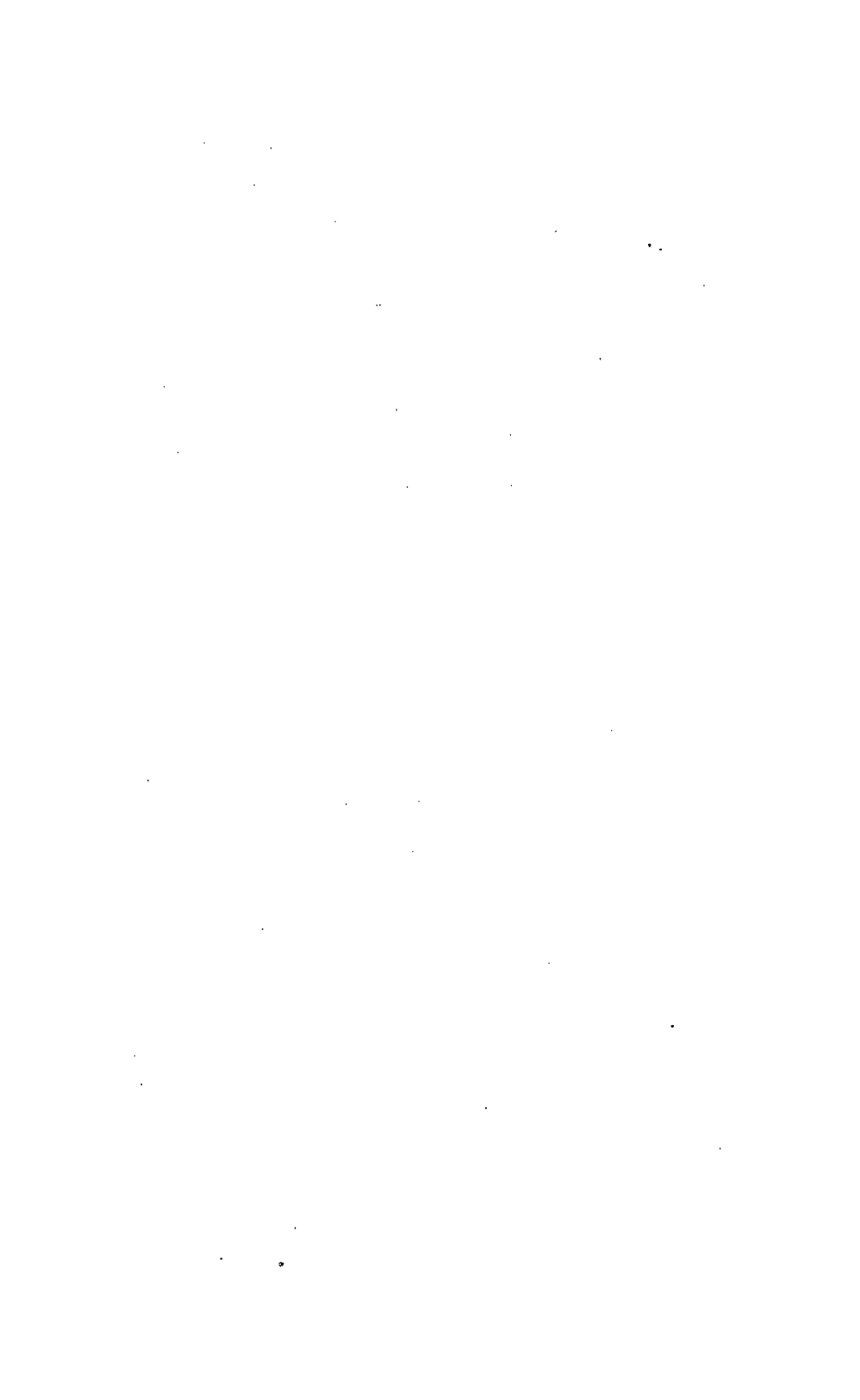




Fig. 1.



Fig. 2.



Fig. 3.



Fig. 4.

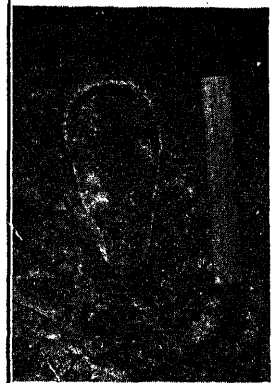


Fig. 5.



Fig. 6.



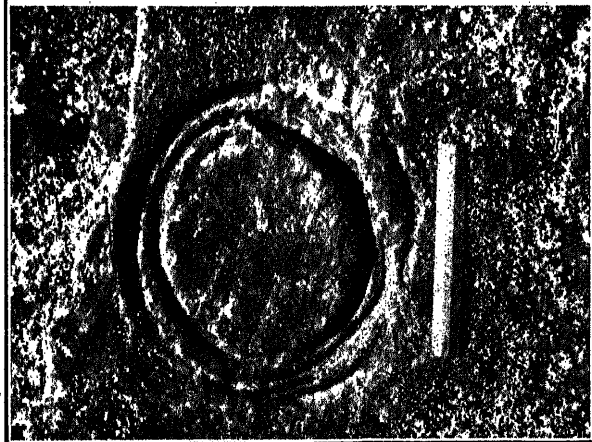


Fig. 1.



Fig. 2.



Fig. 3.



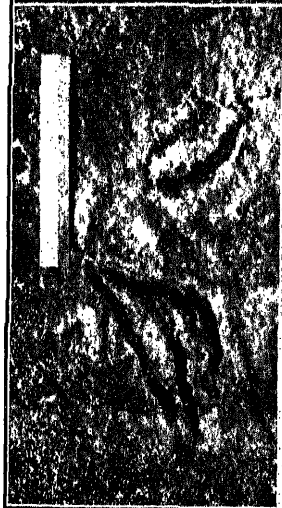


Fig. 1.



Fig. 2.



Fig. 4.

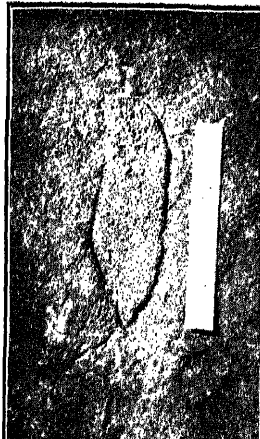


Fig. 3.



Fig. 6.



Fig. 5.





Fig. 1.



Fig. 2.





EXPLANATION OF PLATES.

PLATE II.

The rule shown is 6 inches long.

Fig. 1.—A view of the Mersey Bluff from the air showing its relation to the surrounding country. The part now appearing as fields was originally a dense tea tree (*melaleuca*) scrub. The midden is behind the sandy beach at the base of the bluff, at the bottom of the picture. In the middle background is seen the R. Mersey, and part of the town of Devonport.

Fig. 2.—Most of the carvings are on the steep northern face of the headland or within the 64 feet contour. It is on the northern face that weathering is most pronounced.

PLATE III.

Fig. 1.—Major axis 14.25 cm.; greatest depth, 15mm. The effect of weathering is clearly seen.

Fig. 2.—This and fig. 7 are on the same rock within a few feet of each other.

Fig. 3.—Length, 12 cm.; greatest width, 9.9 cm.; least width, 6.3 cm.; greatest depth, 10 mm., fading away to zero at narrowest part.

Fig. 4.—Larger oval, 8 cm. long, 6.45 cm. wide; smaller oval, 5.9 cm. long, 4 cm. wide. Greatest depth, 3 mm.

Fig. 5.—Major axis, 6.8 cm.; minor axis, 4.3 cm.

Fig. 6.—Length, 10.2 cm.; breadth, 5.59 cm.

PLATE IV.

Fig. 1.—Major axis, 9.85 cm.; minor axis, 8.15 cm. This is uniformly deep, and varies in depth from 16 to 21 mm. The extent and manner of weathering are clearly seen on the right of the carving.

Fig. 2.—Apparently a conventionalised fish. The manner in which the natural cracks of the rock run transverse to the carvings is clearly shown. Length, 32.4 cm.; greatest width, 15.4 cm. At this point there are two deep pits that may have been intended for eyes. Distance between them, 5.55 cm. Greatest depth, 16 mm., is at the top of the figure. Depth of deepest eye pit, 15.5 mm.

Fig. 3.—A very fair representation of the appearance of a Tasmanian snake when coiled. Length along the top, 7.8 cm. Width of the top of the groove at its deepest

part, 5mm., tapering to 1.5 mm. at the bottom. Greatest width of the part representing the head, 2.3 cm.; length of head, 6.35 cm. Length of figure, 10.35 cm. Greatest depth, 17 mm. A great part of this figure is from 15 — 16 mm. in depth.

Fig. 4.—Diameter of the whole carving, 10.65 cm. Major axis of large inner oval, 7 cm.; of small inner oval, 3.8 cm. This is a common form.

Fig. 5.—Major axis, 6.9 cm.; minor axis, 6 cm. Depth, 3 mm.

#### PLATE V.

Fig. 1.—A group of carvings, one of which bears a striking resemblance to a bird's head. The deepest figure possesses the characteristic salient of many carvings. Two feet away on the same rock, is another carving, not shown in the photographs, smaller but of similar design. Length, 13.5 cm.; greatest depth, 17 mm.

Fig. 2.—A deeply incised carving reaching a depth of 26 mm. This seems to be of the same type as Figs. 1 and 4, plate III., with part of the circumference incomplete. Greatest length, 20.8 cm. Length of small oval, 10.2 cm.; width, 6.35 cm. Greatest depth, 26 mm.

Fig. 3.—The only carving that assumes a cup and ring shape. Major axis, 17.8 cm.; minor, 12.7 cm. Greatest depth, 12.5 mm.

Fig. 4.—An incomplete oval. Major axis, 10.8 cm.; minor, 7.5. Uniformly deep. Greatest depth, 13 mm.

Fig. 5.—Length, 15 cm.; greatest breadth, 8 cm. This carving is very close to sea level. Deluged with spray every storm, it is rapidly becoming fainter.

Fig. 6.—Length, 22.85 cm.; greatest width, 8.9 cm. Greatest depth, 13 mm.

#### PLATE VI.

Fig. 1.—Diameter of outer ring (incomplete), 24.4 cm., 22.85 cm. The direction of the natural cracks is clearly shown. Breadth of groove at top, 21 mm.; at bottom, 4 mm. Greatest depth, 16 mm.

Fig. 2.—Greatest length, 20.3 cm. Major axis of oval, 8.9 cm.; minor axis, 7.6 cm.

Fig. 3.—Length of whole figure, 27.95 cm.; width, 20.8 cm. Major axis of pear-shaped figure, 18.3 cm.; minor axis, 15.75 cm.

## PLATE VII.

- Fig. 1.—A leaf-like carving on the left, an irregular oval on the right; both deeply incised. The leaf is 18 mm. in depth, the oval 17 mm.
- Fig. 2.—An excellent example of the way the natural cracks traverse the carvings. This carving is greatly weathered. Major axis of bigger oval, 24.1 cm.; minor axis, 14.6 cm. Major axis of smaller oval, 14 cm.; minor axis, 11.45 cm.
- Fig. 3.—The salient is clearly shown. Length, 17.55 cm.
- Fig. 4.—A deep crescent-shape groove. Distance from tip to tip of horns, 15.3 cm. Greatest depth, 22 mm.
- Fig. 5.—A small weathered carving somewhat similar to fig. 2, plate V. Total length, 8.3 cm.; length of irregular oval, 5.95 cm.
- Fig. 6.—Major axis of larger oval, 9.1 cm.; of smaller, 5.8 cm.

## PLATE VIII.

Both photographs are of the same figure. This is the largest and deepest of the carvings, and seems to be a conventionalised haliotis shell, the haliotis being a common article of food for the natives of this district. When found, the greatest part of this carving was covered with earth. This is the deepest carving yet found, reaching in the top left hand corner a depth of 58 mm. The width of the groove at the top of the widest part is 31.5 mm., but it tapers rapidly. The curl in the left hand segment reaches a depth of 40 mm. Major axis of curl, 15.8 cm. The figure is 58.4 cm. by 57.6 cm.

## STUDIES IN TASMANIAN SPIDERS.

## PART V.

(The Oonopidæ.)

By

V. V. HICKMAN, B.A., B.Sc.

Eleven Text-figures.

(Read 13th July, 1931.)

In the present paper three species belonging to the family *Oonopidæ* are described. The first is the hitherto unknown male of *Tasmanoonops alipes*, Hickman; the second a new species belonging to the genus *Oonopinus*, Simon; and the third a new species belonging to the genus *Orchestina*, Simon. As far as I am aware this is the first record of the two last-named genera occurring in Australia, either in Tasmania or on the mainland. A closely allied genus, *Australoonops*, has been found in Western Australia and *Orchestina* occurs in New Zealand.

## Family OONOPIDÆ.

## Subfamily OONOPINÆ.

Genus *Tasmanoonops*, Hickman.*Tasmanoonops alipes*, Hickman.*Female*. See Proc. Roy. Soc. Tas., 1929, p. 98.*Male*. Measurements in millimetres.

Total Length . . . . .	4.1
Length of Cephalothorax . . . . .	1.8
Width of Cephalothorax . . . . .	1.4
Length of Abdomen . . . . .	2.3
Width of Abdomen . . . . .	1.4

Leg	Femur	Patella	Tibia	Meta- tarsus	Tarsus	Total
1	2.0	0.8	1.8	1.8	0.7	7.1
2	2.2	0.8	1.8	1.5	0.7	7.0
3	1.9	0.7	1.4	1.4	0.6	6.0
4	2.4	0.7	1.9	1.9	0.7	7.6
Palpi	0.9	0.4	0.3	—	0.7	2.3

*Cephalothorax*: Yellowish brown; strongly narrowed in front, rounded at the sides and emarginate in rear. Longer than wide in ratio 9 : 7. Median furrow absent. Clothed with short recumbent hairs.

*Eyes*: Six. Oval in shape, mounted on black rims. The ocular area is almost as wide as the anterior part of the cephalothorax. A few long bristles are found in front and at the side of the eyes. The median eyes are contiguous and the front and rear laterals are also contiguous. The median eyes are separated from the front laterals by a space equal to about one-third of their long diameter. When viewed from above the median eyes appear to form a straight line with the front laterals. The eyes are subequal in size.

*Clypeus*: Narrow, the distance from the base of the chelicerae to the median eyes being about equal to half the long diameter of the eyes. It is clothed with coarse black bristles which project forward.

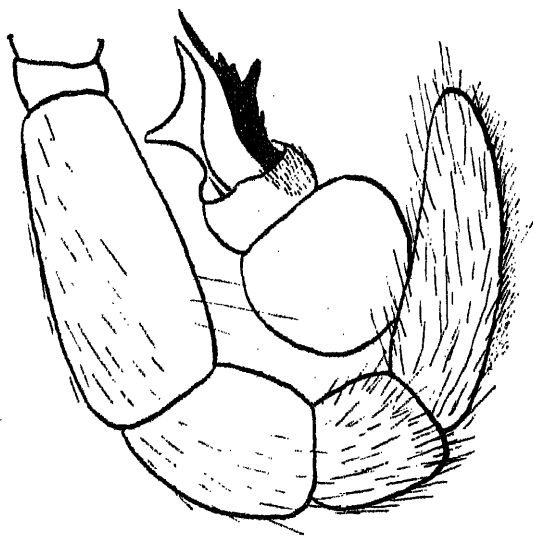


Fig. 1. *Tasmanoonops alipes*, Hickman.  
Left palp of male viewed from outer side.

*Legs*: 4, 1, 2, 3. Yellowish brown, clothed with short, finely barbed hairs. A single trichobothrium is present on each metatarsus near the apex and two trichobothria on each tibia, elsewhere none. The tarsal claws are carried on a well-developed onychium. The claws resemble those of

the female, but the wing-like projections on the superior claws are not as large as in the female. The onychium is furnished with spatulate hairs and with five long barbed hairs. The tarsi are short.

*Spines*: The first and second pairs of legs have no spines. *Third leg*. Femur 0. Patella 0. Tibia-dorsal 0, prolateral 1 - 1 - 1, retrolateral 0, ventral 1 near apex. Metatarsus-dorsal 0, prolateral 1 - 1 - 1, retrolateral 0, ventral 1 in the middle and 1 apical. *Fourth leg*. Femur 0. Patella 0. Tibia-dorsal 0, prolateral 1 - 1 - 1, retrolateral 1 - 1 - 1, ventral 1 - 1 and 2 apical. Metatarsus-dorsal 0, prolateral 2 - 1d - 1v - 2, retrolateral 2 - 1 - 2, ventral 1 and 2 apical. No spines are present on any of the tarsi.

*Palpi*: The tarsal segment is long and finger-like. Its dorsal surface is thickly clothed with short hairs. The bulb is yellow and nearly spherical. It is attached near the base of the segment and is furnished with a peculiar embolus and conductor. (See Fig. 1.) When viewed from the outer side the embolus appears as a dark coloured serrated projection rising from a chitinous cup, which on one side is produced into a twisted, subtriangular conductor. The wall of the cup is not continuous on the inner side. Near the base of the conductor is found a spine-like projection. The femur, patella, and tibia are short and stout.

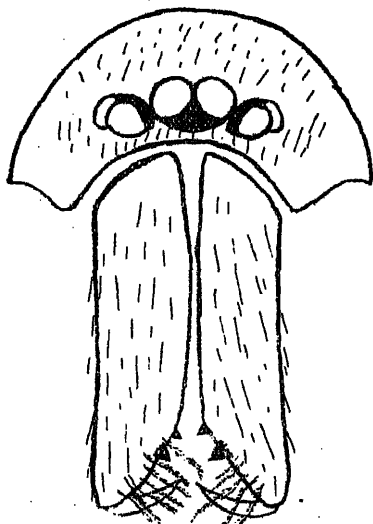


Fig. 2. *Tasmanooonops alipes*, Hickman.  
Falces and eyes of male viewed from front.

*Chelicerae*: Long, narrow, and parallel, clothed with a few short setae. Fang well curved. Promargin of furrow armed with a single tooth. Retromargin also armed with one tooth. Long barbed hairs on the promargin as in the female. (See Fig. 2.)

*Labium, Maxillae, and Sternum* as in the female.

*Abdomen*: Ovate, grey, marked with numerous faint spots. It is clothed with finely barbed hairs. Two pairs of spiracles are present in the same position as described for the female. One pair leads into book-lungs, the other into tracheae.

*Spinnerets*: Six. They resemble those of the female, but the peculiar ventral spines are replaced by short bristles.

*Locality*: The Great Lake (3,350 feet). 15th March, 1930.

*Field Notes*: Only one specimen was collected. It was found under a stone near the northern end of the lake.

#### Genus *Oonopinus*, Simon.

##### *Oonopinus mollipes*, sp. nov.

*Female*. Measurements in millimetres.

Total Length . . . . .	2.24
Length of Cephalothorax . . . . .	0.82
Width of Cephalothorax . . . . .	0.64
Length of Abdomen . . . . .	1.43
Width of Abdomen . . . . .	1.00

Leg	Femur	Patella	Tibia	Meta-tarsus	Tarsus	Total
1	0.67	0.25	0.53	0.50	0.36	2.31
2	0.64	0.25	0.53	0.50	0.28	2.20
3	0.43	0.21	0.36	0.39	0.25	1.64
4	0.64	0.25	0.46	0.50	0.25	2.10
Palpi	0.35	0.11	0.14	—	0.25	0.85

*Cephalothorax*: Dark brown, convex, cephalic part moderately high, not marked with any pattern, but clothed with a few coarsely barbed hairs.

*Eyes*: Six. The eyegroup is compact and about two-thirds the width of the head. The eyes are of an irregular oval shape. The laterals are equal in size, but the central eyes are longer than and not as wide as the laterals. Front and rear laterals are contiguous. The central eyes are also contiguous with each other, and with the front edge of the



anterior lateral eyes. The space inside the eyegroup is pigmented with black. When viewed from above the central eyes form a slightly procurved row with the front laterals and a strongly recurved row with the rear laterals. (See Fig. 3.)

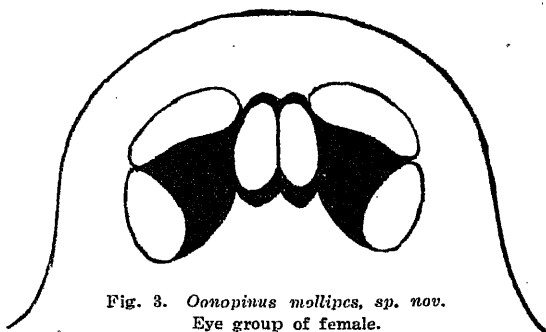


Fig. 3. *Oonopinus mollipes*, sp. nov.  
Eye group of female.

*Clypeus*: Narrow, the distance from the base of the chelicerae to the front edge of the central eyes being about equal to the long diameter of these eyes.

*Legs*: 1, 2, 4, 3. Brown, clothed with coarsely barbed hairs. Two trichobothria on each tibia and one near the apex of each metatarsus. The tarsi end in an onychium which carries two claws. Each claw has a double row of short, blunt teeth, there being about eight teeth on each side of the claw. The tip of the claw is finely serrated. The hairs on the onychium are not spatulate, but are barbed and different from the hairs covering the other parts of the legs. (See Fig. 4.)

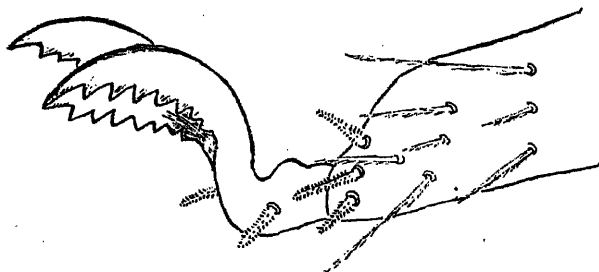


Fig. 4. *Oonopinus mollipes*, sp. nov.  
Tarsal claws of female.

*Palpi*: Colour and clothing like that of the legs; the tarsal segment is very thickly clothed with barbed hairs. Claw absent.

*Spines*: No spines are present on either legs or palpi.

*Chelicerae*: Brown, conical, clothed with a few hairs like those on the legs. Fang curved and slender. No teeth on margins of furrow.

*Maxillae*: Brown, narrow, long, and converging; clothed with a few coarsely barbed hairs. (See Fig. 5.)

*Labium*: Brown, triangular, its width at the base being equal to its length. (See Fig. 5.)

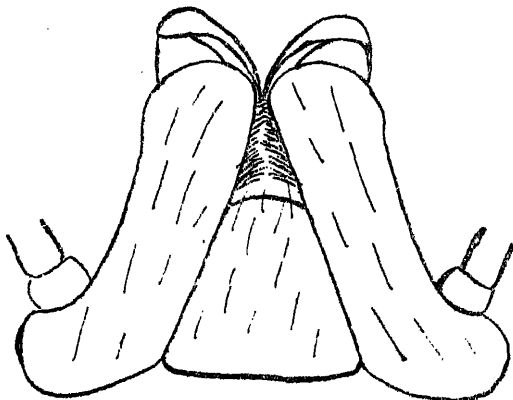


Fig. 5. *Oonopinus mollipes*, sp. nov.  
Maxillae and labium of female.

*Sternum*: Brown, shiny, convex, as long as wide; produced between rear coxae, which are separated by little more than their diameter. The middle area of sternum is smooth and devoid of hairs, but round the margin it is clothed with coarsely barbed hairs. First coxae wide apart. In outline the sternum is cordiform.

*Abdomen*: Ovate, brownish grey above, the rear half being marked with a longitudinal patch of lighter colour. The ventral surface light fawn. Two pairs of spiracles. The anterior pair are placed one on each side of the body in front of the epigastric furrow and open into book-lungs. The posterior pair are immediately in rear of the furrow and somewhat nearer the central line. They open into tracheae.

*Spinnerets*: Six. The anterior pair larger than the others.

*Locality*: Trevallyn, Launceston. 27th May, 1930.

*Field Notes*: Collected in grass tussocks. Three female specimens were found.

Genus *Orchestina*, Simon.*Orchestina launcestoniensis*, sp. nov.*Male*. Measurements in millimetres.

Total Length . . . . .	1.22
Length of Cephalothorax . . . . .	0.58
Width of Cephalothorax . . . . .	0.43
Length of Abdomen . . . . .	0.73
Width of Abdomen . . . . .	0.58

Leg	Femur	Patella	Tibia	Meta- tarsus	Tarsus	Total
1	0.51	0.15	0.47	0.36	0.24	1.73
2	0.51	0.15	0.48	0.44	0.24	1.82
3	0.35	0.14	0.28	0.32	0.21	1.30
4	0.53	0.15	0.37	0.44	0.24	1.73
Palpi	0.17	0.07	0.22	—	0.17	0.63

*Cephalothorax*: Yellowish brown, marked with regular dark brown lines as in the female. (See Fig. 6.) Convex, the highest point being between the third coxæ. From here it slopes gradually to the front and somewhat more steeply to the rear. Sides rounded and margined with dark brown. A few long erect hairs are scattered over the surface.

*Eyes*: Six. The lateral eyes are equal in size and contiguous. The median eyes are oval in shape, contiguous, and larger than the lateral eyes in ratio 5 : 4. They are separated from the anterior lateral eyes by a space equal to one-fifth of their own long diameter. When viewed from above the median eyes and the anterior laterals form a slightly recurved row. All the eyes are pearly white and mounted on black rims. (See Fig. 6.)

*Clypeus*: Height slightly less than the long diameter of a median eye. Clothed with a few long coarse hairs.

*Legs*: 2, 1, 4, 3. Yellowish brown, clothed with long finely barbed hairs. A single trichobothrium at the apex of each metatarsus and two trichobothria on each tibia. Rear femora very much dilated. Tarsi provided with an onychium which carries two claws. In microscopic preparations each claw is seen to be provided with two rows of teeth. The outer row consisting of five or six teeth, which increase in size towards the base of the claw and the inner row consisting of two or three small teeth.

*Palpi*: Bulb large and pyriform. Tibial segment strongly dilated. The long sperm duct may be clearly seen inside

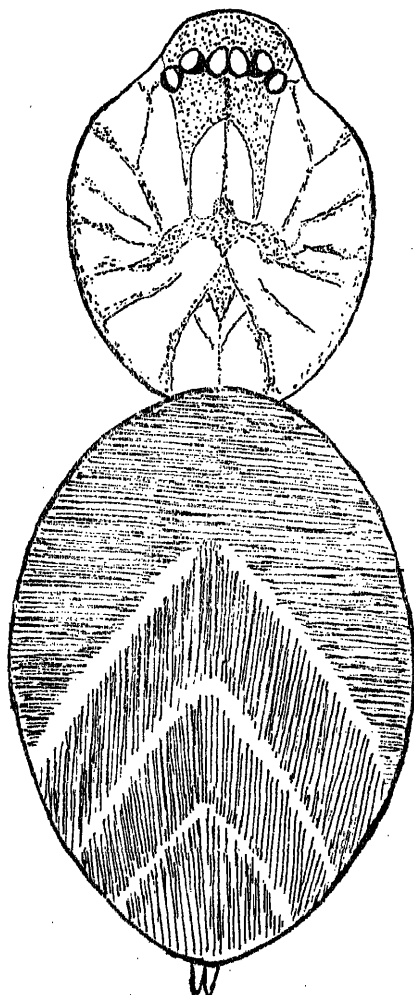


Fig. 6. *Orehestina launcestoniensis*, sp. nov.  
Cephalothorax and abdomen of female.

the bulb. It forms a spiral consisting of two complete turns and two half turns near the base of the bulb. The embolus is short, curved, and black. The tarsal segment is spoon-shaped. Its length is shorter than the width of the bulb in ratio 4 : 5. (See Fig. 7.)

*Spines*: There are three spines at the apex of the fourth metatarsi. Elsewhere none.

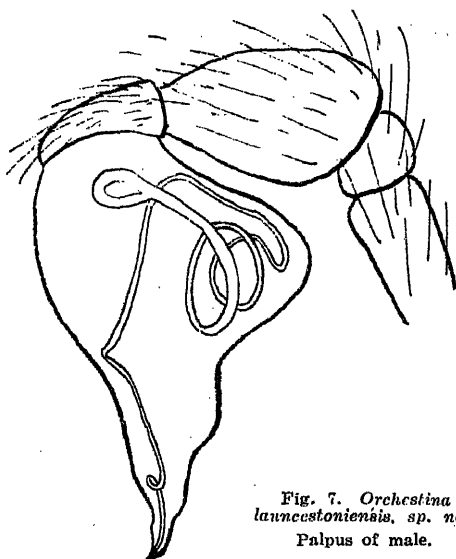


Fig. 7. *Orchestina launcestoniensis*, sp. nov.  
Palpus of male.

*Cheliceræ*: Slender and conical. Fang strong and well curved. Margins of furrow not armed with teeth, but the inner surface of the paturon is studded with minute conical spines. A light scopula of barbed hairs on promargin of furrow. (See Fig. 8.)

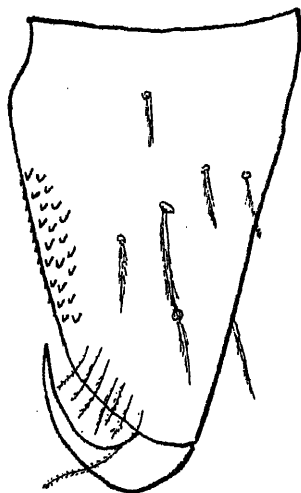


Fig. 8. *Orchestina launcestoniensis*, sp. nov. ♀  
Chelicera showing minute teeth on inner surface of paturon.

*Maxillæ*: Inclined over labium. The apical quarter is divided into two lobes. When the mouth parts are carefully dissected it is found that one lobe is pale yellow and carries a light scopula of finely barbed hairs. The other lobe is ventral to the former and has the shape of a narrow, dark brown projection, which points forward. It carries a well-developed serrula and ends in a slightly curved tip. (See Fig. 9.)

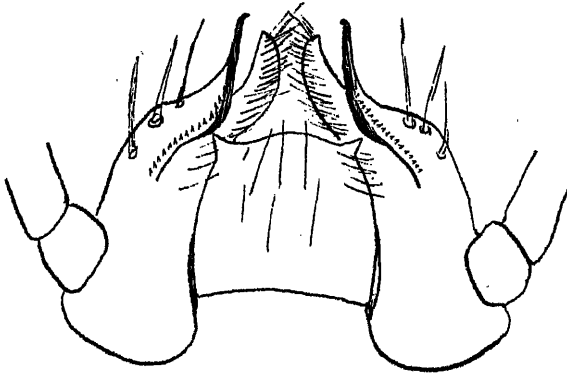


Fig. 9. *Orchestina launcestoniensis*, sp. nov.  
Labium and maxillae of male.

*Labium*: Rounded in front and at the sides. The front margin produced into a point on each side. This point appears to fit between the two apical lobes of the maxilla. (See Fig. 9.)

*Sternum*: Yellowish, moderately convex, cordiform; separated by a deep groove from the labium and produced between the rear coxæ.

*Abdomen*: Ovate. Dark brown above, fawn underneath. Dorsal surface is marked with three chevrons as in the female. (See Fig. 6.) The area in front of the anterior chevron is finely striated with dark transverse lines. The area in rear is marked with fine longitudinal lines. The clothing consists of long hairs mingled with short hairs. Two pairs of spiracles as in female.

*Spinnerets*: Six. Anterior pair larger than the others. Middle pair very slender.

*Female*. Measurements in millimetres.

Total Length . . . . .	1.33
Length of Cephalothorax . . . . .	0.64
Width of Cephalothorax . . . . .	0.46
Length of Abdomen . . . . .	0.75
Width of Abdomen . . . . .	0.64

Leg	Femur	Patella	Tibia	Meta- tarsus	Tarsus	Total
1	0.49	0.17	0.43	0.40	0.22	1.71
2	0.49	0.17	0.43	0.43	0.22	1.74
3	0.37	0.15	0.28	0.30	0.18	1.28
4	0.56	0.18	0.29	0.44	0.19	1.66
Palpi	0.17	0.08	0.12	—	0.17	0.54

*Cephalothorax*: Ovate, convex, highest point between the third coxæ. Marked with a regular pattern of dark lines on a yellowish brown ground. Margin with a brown edge. Surface clothed with a few long erect hairs. (See Fig. 6.)

*Eyes*: Six. Mounted on black rims. Oval in shape. Median eyes separated from the front laterals by one-third of their own diameter. The lateral eyes are equal in size and contiguous. The median eyes are also contiguous and slightly larger than the laterals in ratio 6 : 5. The front laterals and the median eyes form a slightly recurved row, when viewed from above.

*Clypeus*: Clothed with a few long hairs. Its height is equal to two-thirds of the long diameter of a median eye.

*Legs*: 2, 1, 4, 3. Yellowish brown, clothed with finely barbed hairs. A single trichobothrium near the apex of each metatarsus and two on each tibia; elsewhere, none. Rear femora dilated. Tarsi end in an onychium. Two tarsal claws are present. Each claw has a double row of teeth, three small teeth on the inner side and seven larger teeth, which increase in size towards the base, on the outer side. (See Fig. 10.)

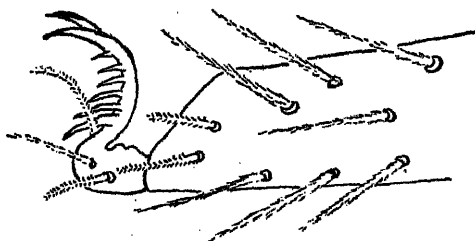


Fig. 10. *Orchestina launcestoniensis*, sp. nov. ♀  
Tarsal claws, showing teeth on outer side.

*Spines*: Absent from all the legs.

*Chelicerae*: Conical and slightly stronger than those of the male. Fang well curved. Margins of furrow without

teeth. The inner surface of the paturon armed with minute conical spines. A light scopula of barbed hairs on pro-marginal of furrow. (See Fig. 8.)

*Maxillæ*: Narrow, converging over labium. Apical portion normal and not divided into two lobes as in the male. Provided with a light scopula of barbed hairs on inner side. Serrula present on outer side. (See Fig. 11.)

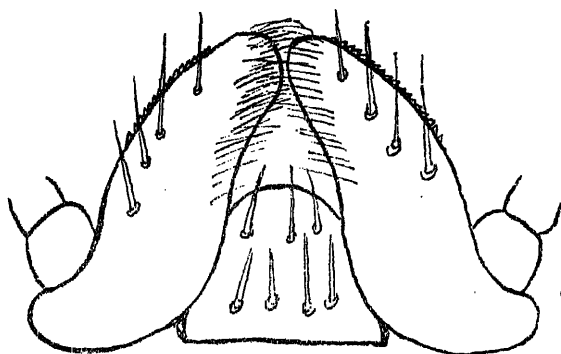


Fig. 11. *Orchestina launcestoniensis*, sp. nov.  
Labium and maxillae of female.

*Labium*: Rounded in front and at the sides. Not produced into a conical point on each side of front margin. Its sides are slightly overlapped by the maxillæ, making it difficult to see without dissecting the mouth parts.

*Sternum*: As in the male.

*Abdomen*: Ovate, brownish above, fawn underneath. The dorsal surface is marked with three chevrons and striated as in the male. (See Fig. 6.) Two pairs of spiracles are present. The anterior pair are placed one on each side immediately in front of the ends of the epigastric furrow. The posterior pair are close behind the furrow and a little nearer the middle line.

*Spinnerets*: As in the male.

*Locality*: Punch Bowl, Launceston. 24th May, 1930.

*Field Notes*: This little spider is very common in grass tussocks. When touched, it jumps backward. This habit is no doubt correlated with the strong development of the femora of the fourth pair of legs.

*Types*: In the Queen Victoria Museum, Launceston.



# NOTES ON THE FOSSIL SPORES IN AN OIL-SHALE FROM TASMANIA.

By

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Formerly Lecturer in Botany at the University of Lucknow.

(Communicated by P. B. Nye, M.Sc., B.M.E.)

Plate IX. and Three Text-figures.

(Read 13th July, 1931.)

*Tasmanite* is an oil-shale known to occur in the Permo-carboniferous (1) of the North and North-Western districts of Tasmania. The shale is of sedimentary origin and is brownish grey in colour, being largely impregnated with spores which have been named by Newton as *Tasmanites punctatus* Newt. (2). On distillation the shale yields an artificial petroleum which is claimed to be obtained from these spores (3). Thus it is chiefly for its economic importance rather than palæo-botanical that it has been engaging the attention of investigators from time to time.

During the course of an examination of these spores, few points have come to notice which deserve mention.

As stated above, the shale is mainly composed of spores. They appear—even with the naked eye—as flattened circular dot-like bodies, thousands of them sticking to the fine-grained arenaceous matrix. When a small piece of the shale is gently crushed and stirred under water in a petri-dish, the spores, being lighter, separate off from the heavy sandy particles. On treatment with *Diaphanol* they become somewhat bleached and show the structure more clearly. They, however, are rather averse to taking up stains except for a little of Safranin.

When not damaged the spores are circular and are of varying size (fig. 1)—200  $\mu$  to 533  $\mu$  in diameter (4). The

(1) McIntosh Reid, A. (1926), p. 43.

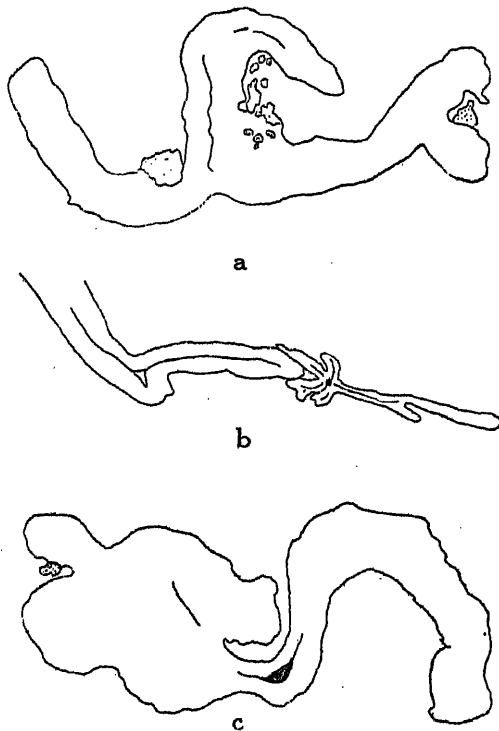
(2) Newton, E. T. (1875), p. 341.

(3) McIntosh Reid, A. (1924), pp. 35-37.

(4) Measurements of a dozen and a half representative spores taken at random, are as follows:—200 $\mu$  x 283 $\mu$ ; 233 $\mu$  x 233 $\mu$ ; 250 $\mu$  x 275 $\mu$ ; 266 $\mu$  x 233 $\mu$ ; 283 $\mu$  x 316 $\mu$ ; 291 $\mu$  x 308 $\mu$ ; 316 $\mu$  x 333 $\mu$ ; 333 $\mu$  x 350 $\mu$ ; 333 $\mu$  x 366 $\mu$ ; 358 $\mu$  x 333 $\mu$ ; 366 $\mu$  x 450 $\mu$ ; 400 $\mu$  x 433 $\mu$ ; 416 $\mu$  x 425 $\mu$ ; 433 $\mu$  x 450 $\mu$ ; 450 $\mu$  x 466 $\mu$ ; 466 $\mu$  x 500 $\mu$ ; 500 $\mu$  x 500 $\mu$ ; 500 $\mu$  x 533 $\mu$ .

punctated surface to which Newton alludes (5), is not at all seen in any of my slides, instead, in favourable cases characteristic surface-sculpturings have been observed (figs. 2, 4, 5, 7, and 8). In others these surface-sculpturings seem to have been rubbed off during fossilisation. In certain spores distinct tri-radiate marks (fig. 3) are clearly visible.

Serial microtome sections (6) (figs. 10-12 and text-figs. a-c) were cut with a view to seeing the presence of cell-contents, but the result has so far turned out to be negative. However, one thing is plainly evident, namely that the spores appear to have been pressed hard during fossilisation in



Text-figures a-c. (Camera-lucida sketches.) Microtome sections of spores, showing peculiar shapes. (The dotted shading represents the sand-particles.)

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(5) Newton, E. T. (1875), p. 341.

(6) Sections as thin as  $6\mu$  have been microtomed with ease. The process is dehydration, etc., is exactly similar as employed in usual micro-technique.

various planes, and have thus been reduced to thin strips, which show slight stratification. Not unoften, the spores ruptured only on one side may be met with (fig. 6). The shape of the spores is determined by the planes of the strata abutting on them, such that they present often very peculiar shapes in section (fig. 12 and text-figs. a-c).

### DISCUSSION.

These spores have variously been regarded by different (7) authors as resin, marine deposit, algæ of spherical form, spores, and sporangia. The present observations, however, lend support to the last view. The demonstration of a tri-radiate mark and surface-sculpturings removes the suspicion of the algal nature of the spores.

Newton, supported by others, has made a suggestion that "their (spores) form and size seem to indicate that they are "more nearly allied to Lycopodiaceous macrospores than any- "thing else" (8). An experiment performed in this connection by Stewart (9) is rather significant. He, on distillation of a mixture of 25 per cent. of Lycopodium powder and 75 per cent. of fuller's earth was able to condense a substance similar to the shale-oil obtained from the *Tasmanite*. But an examination of the surface characters of the spores of the living Lycopods (10) does not show any identity with those of *Tasmanites punctatus*. At the same time, it is rather curious that no fossil Lycopods, or even their allies, have so far been recorded near about the same horizon from Tasmania (11). The only members from the same strata as the oil-shale, are either Gymnosperms or one of the Equisetales—*Phyllothea australis* Brong. (11). With such incomplete data before us, it is rather unsafe to relate these spores to one or the other until some positive evidence is forthcoming.

Considerable variation in the size of spores has suggested some authors to think that they include a mixture of both micro- and macro-spores, but this does not seem to be tenable, because even the smallest spores are rather too big to be regarded as microspores as compared with the bigger ones, and besides this nothing of the like is known in any other fossil plant so far. There may, however, be another possibility, namely, that they are derived from closely

(7) Twelvetrees, W. H. (1911), Bull. 11.

(8) Newton, E. T. (1875), p. 341.

(9) Stewart, D. R. (1912), pp. 164-5.

(10) I am thankful to Prof. M. O. P. Iyengar, of Madras, who was kind enough to send me spores of certain living Lycopods. This helped me a good deal in making comparisons.

(11) Sahni, B. (1926), p. 325.

related species of plants. If this is true, then more than half-a-dozen species may be involved. Nevertheless, the shape and structure of the spores are so very similar that they suggest being derived from a single species. This variation in size seems to be due to a mixture of mature and immature spores. Such a polymorphic phenomenon is quite common among vascular plants (12).

#### SUMMARY.

An examination of the fossil spores present in *Tasmanite* has been made, and the following results have been obtained:—

- (1) The surface of the spores is not punctated (in my specimen) as stated by Newton, but instead has definite sculpturings.
- (2) Tri-radiate mark on the spores is present in favourable cases.
- (3) These spores have been microtomed for the first time.
- (4) The spore-wall in section often shows slight stratification.
- (5) These spores are averse to taking up any stain except a little of safranin.
- (6) The suggestion of their Lycopod-origin is doubted.
- (7) Variation in the size of spores is due perhaps to the mature and immature spores being mixed together.

#### ACKNOWLEDGMENTS.

I have great pleasure in recording my sincere thanks to Dr. Pascoe, Director of the Geological Survey of India, for having allowed me the use of reference books kindly sent out to me from the library of the Geological Survey; to Mr. A. McIntosh Reid, Director of Mines, Tasmania, for the specimen which he kindly sent me at my request in December of 1927.

BHOWALI (Nainital Hills),

Oct. 9th, 1930.

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- (12) Bower, F. O. (1923), pp. 263-4.  
 Singh, T. C. N. (1929), p. 207.  
*Ibid.* (1930), p. 21.  
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#### EXPLANATION OF THE PLATE.

(All are camera-lucida sketches, and the shaded area in the figures denotes the sand-particles yet sticking to the spores.)

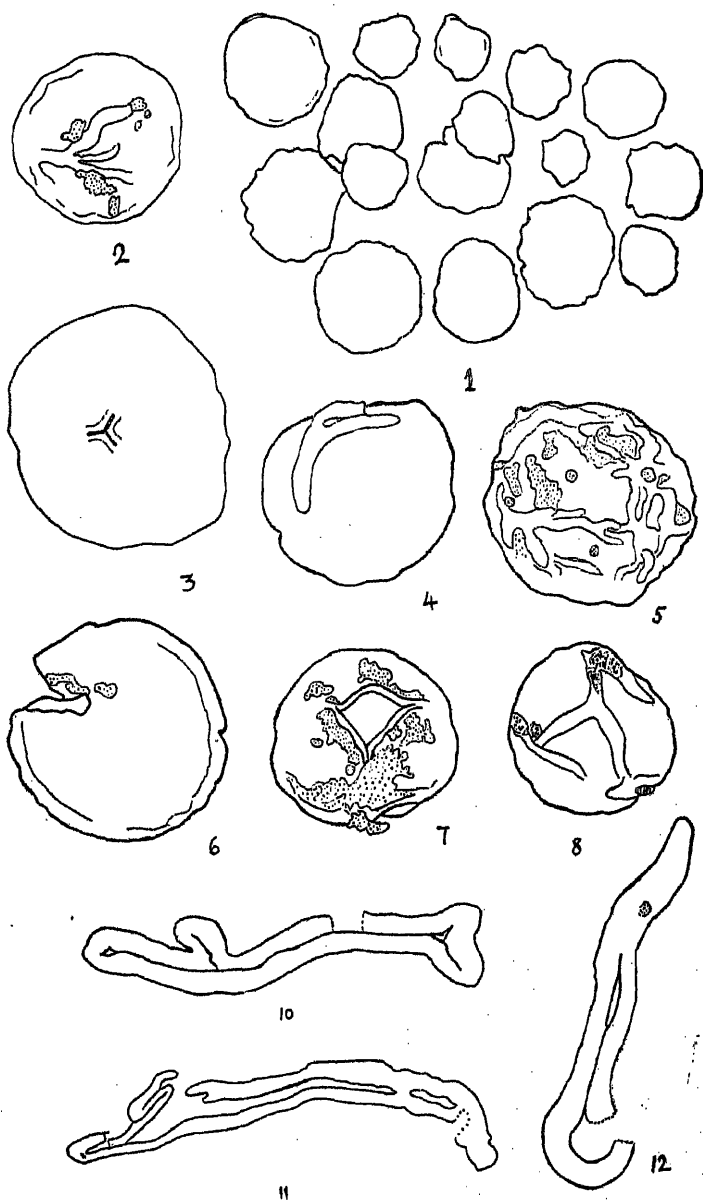
Fig. 1. Spores of various sizes. X 44.

Figs. 2, 4, 5, 7, 8. Spores with surface sculpturings, fig. 5 being typical. Figs. 2 & 7 — X 102; Figs. 4-5 — X 92; Fig. 9 — X 126.

Fig. 3. A spore with a distinct tri-radiate mark. X 100.

Fig. 6. A spore ruptured on a side, showing the mouth-like fold. X 102.

Figs. 9-11. Microtome sections of spores. X 203.



*Tasmanites punctatus.*



ON THE STRUCTURE OF THE RESPIRATORY  
ORGANS OF THE  
TERRESTRIAL ISOPODA.

By  
ERNEST E. UNWIN.

Plates X.-XVII.

(Read 18th July, 1931.)

1. INTRODUCTION.

Terrestrial isopods present problems in respiration because of their change of habitat. With organs of respiration which are homologous with the branchiæ of *Asellus* and other aquatic isopods, they live on land and breathe air. They are found in very varied situations; some require very wet conditions, others can live in comparatively dry places.

In this communication I propose to describe the interesting anatomical features of the respiratory organs of certain species.

In the species treated of, and in the *Oniscoidæ* generally, five pairs of abdominal appendages take some part in respiration. I propose to describe these appendages in the female forms only. There are no differences in the essential points of histology and physiology between the male and female pleopods, and the fact that, in the male, reproductive processes are associated with the 1st and 2nd pleopods, brings in an unnecessary complication.

*Methods.*

*Living Specimens:* I have indicated the methods in use for examining the abdominal appendages *in situ*.

*Abdominal appendages as flat objects:* Methylene blue, as a stain for living tissue, as well as for fixed ones, is most useful. Prussian blue gelatine injection has been used to investigate the limits of blood cavities.

*Paraffin serial sections:* For fixing I have found Fleming's solution the best. Hot 80 per cent. alcohol has given good results with some.

*Staining:* Delafield's hæmatoxylin followed by eosin in 90 per cent. alcohol. The staining has been done on the slide in dipping jars.



## II. SPECIES DEALT WITH.

1. *Trichoniscus pusillus*, Br.

## Pl. X., figs. 1-6.

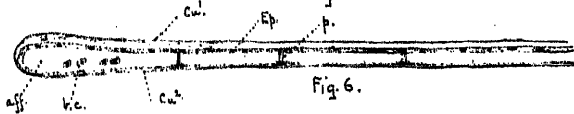
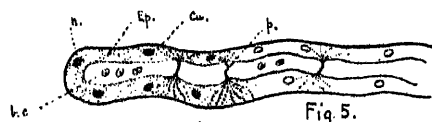
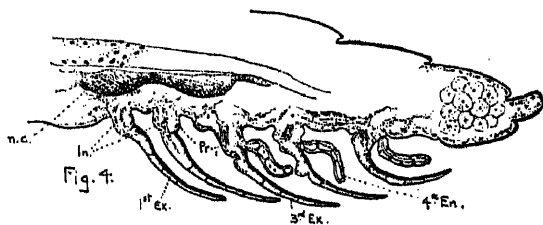
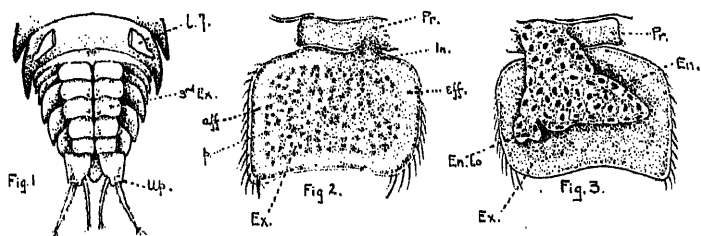
The ventral surface of the abdomen is shown in Fig. 1. It is covered by five pairs of oval plates, which overlap from before backwards, and those of either side meeting together in the mid-ventral line.

Normally each of these plates indicates an abdominal appendage, consisting of a basal part, an outer plate (exopodite) and an inner plate (endopodite), but the endopodites are missing from the first two pairs of appendages. Thus there are five pairs of exopodites and three pairs of endopodites. These are the respiratory organs.

In many forms the structure of all the exopodites is similar and the same applies to the endopodites; it will be convenient, therefore, to take the 3rd abdominal appendage for special study as this is the first complete appendage. Where differences exist between the exopodites of the 1st and 2nd abdominal appendages and that of the 3rd, the description will be extended to include them.

Figs. 2 and 3 show the 3rd abdominal appendage seen from the ventral or outer, and from the dorsal or inner aspect. The exopodite acts as an operculum for its rather smaller and more delicate endopodite. Each plate takes part in respiration. This has been made clear by observation, by experiment, and by the evidence afforded by sections. If a living specimen is observed under a low power of the microscope, the abdominal appendages seem covered with a film of water, at least the endopodites are, for as the exopodites are raised and lowered—an action which, although not absolutely regular, is fairly continuous when the creature is not moving and which is a breathing action—a film of water retreats and advances under the free edges of the exopodites. This shows that the endopodites are kept very wet and are used for respiration in a very damp condition. By using a higher power the circulation of blood can be observed in the exopodites. They are well supplied with blood, and act as additional breathing organs. I proved this by putting the endopodites out of action, in this and in other woodlice, by inserting some vaseline under the exopodites. The creatures lived for very considerable periods. In the control experi-

TRICHONISCUS pusillus ♀.



EEU 44

*Trichoniscus pusillus* ♀.



ment with the whole of the ventral surface of the abdomen made impervious, the woodlice did not live more than two days at the longest.

It is also clear from the transverse sections that the exopodites are used as organs for respiration, and that the outer or ventral surfaces function to this end. The chitinous cuticle of the ventral or outer wall—the wall towards the air, the oxygen medium—is very thin and the inner or dorsal wall quite thick. If the exopodite functioned as an operculum solely, the outer or ventral wall would be the thicker, as it is for instance in the 3rd abdominal exopodite of *Asellus*. This will be referred to below when the transverse sections are described in detail.

We shall find as we study the woodlice adapted for drier situations, that the exopodites become more and more important as breathing organs. It is in the exopodites that accessory breathing organs are developed; and the endopodites, although three pairs are always present, become less important in consequence.

*The Exopodite:* The exopodite is roughly oval in outline. (Fig. 2.) When seen under the microscope as a transparent object, either in the fresh living condition or treated with methylene blue, the surface is covered with small dots, which are not arranged evenly over the surface. These dots are the nuclei of the epithelial layer, and here and there where they are grouped together comes an inter-lamellar pillar or bridge (le pilier of Kimus (1)). The space between the two walls traversed by these pillars is the blood cavity. There are no definite blood vessels, but at the sides of the appendage channels can be seen, free from pillars. These are the inhalent and exhalent blood channels, or afferent and efferent canals. It has already been noted that the circulation of the blood can be seen. This is due to the large size of the blood corpuscles. The blood collects into a large ventral sinus in the abdomen and is drawn through the abdominal plates by the pumping action of the heart, which, receiving purified blood, propels it forward to the head and to the body generally. The blood enters the exopodite at the point of attachment, and runs along the inner border in what we may call the afferent canal, finds its way between the two lamellæ, into the efferent canal along the outer border, and so out of the appendage. The blood is prevented from short circuiting from the afferent to the efferent in

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(1) Kimus (see Bibliography).

the proximal part of the exopodite by the presence of a tissue which is continuous with and similar to the tissue found in the body cavity. This is the intermediary tissue to use the name suggested by Kimus (le tissu intermédiaire).

If the exopodite be examined by transverse or longitudinal section (Figs. 4 and 6), the details of the two walls or lamellæ can be seen. Each lamella consists of an epithelial part and a cuticle, and the two lamellæ are very different. The inner or dorsal wall has a fairly thick cuticle, and the epithelial lining is quite distinct with its nuclei at frequent intervals. This epithelial lining is a single layer of cells which give rise to the cuticle on its outer face. The cuticle of the outer or ventral wall (or lamella) is very thin, and the epithelial lining is also extremely thin, indeed in most sections it is not seen except in the region of the pillars, but at the time of the formation of a new cuticle the layer is distinctly seen. In a later communication I have described and figured a section through an exopodite at the time when this layer shows best of all (Pl. XIII., fig. 28). Sometimes the very thin remains of the layer is seen when by some action (osmosis) the protoplasmic lining becomes distorted. The pillars pass from cuticle to cuticle. The outer wall of the exopodite is thus adapted for respiration through its very thin wall; the inner wall for protection and for the necessary support of the exopodite itself (Fig. 6).

Stoller (2), to whose work upon the breathing organs of woodlice I shall have occasion to refer and to correct in many important particulars, does not describe *Trichoniscus*, but refers very briefly to *Ligidium hypnorum*. He says, referring to a cross section of the exopodite of which he gives a figure:

"It is seen that the gill (= exopodite) is in principle a simple sac containing blood. The outer layer of the wall, composed of chitine, is much thicker on the ventral than on the dorsal side of the gill. The hypoderm (= epithelium) everywhere lines the chitine, and in general varies with it in thickness."

This is the exact opposite of what I find in *Trichoniscus*, and at first I thought that this section of *Ligidium* must have become turned round in some way, or that we were using the terms "dorsal and ventral" in different ways, but a few lines further on he makes it quite clear that he looks upon the inner surface (that is the dorsal surface as the plates are found *in situ*) as the respiratory one, and that it is in

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(2) Stoller (see Bibliography).

use when the air enters the space in which the endopodite lies. By the following extract it is clear that he imagines only one kind of respiration—that taking place in the endopodite cavity, whereas the outer surface of the exopodite is adapted for respiration of a different kind. (See Summary.)

"It is true that as the blood circulates through the gill, it is separated from the external atmosphere by the rather thick ventral wall of chitine. But through the movements of the gill, taking place as described for *Porcellio*, air is constantly brought into relation with the inner surface where the chitinous wall is thin." (Stoller.)

It will be best to correct at once this serious mistake in Stoller's account, for it occurs in his descriptions of other species. In his description of the last three pairs of exopodites of *Porcellio scaber*, which are more or less normal in structure and do not possess the air-tree organs, he describes their function as protective covers for the endopodites and their movement causing renewal of air to the endopodites. I agree in these two functions, but do not agree with the observation given below as to the structure of the wall.

"It is possible that the outer gills (= exopodites) in addition to performing these functions, constitute in themselves organs of respiration. The blood circulates between the two walls of the gills, and whether respiration takes place depends upon the penetrability of the walls to the gases to be exchanged. The ventral wall of chitine is thick—thicker than the chitinous wall in some other regions of the body as, for example, the thoracic legs (in which also the blood circulates). The dorsal wall is, on the other hand, moderately thin. It is, moreover, exposed to the moist air in the chamber in which the inner gills lie. It would seem probable, therefore, that to some extent respiration may take place through the dorsal wall." (Stoller.)

This extract goes to show that in Stoller's mind the dorsal wall, the one that is applied to the endopodite, is considered thinner than the ventral wall, the one that is bathed by the external air. I have examined all the common species of woodlice and find the opposite arrangement in every case (except where a great change like the development of an air-tree organ has altered the exopodite). In *Ligia oceanica*, *Trichoniscus pusillus* and *roseus*, *Oniscus asellus*, *Philoscia muscorum* and *conchii*, *Porcellio scaber*,

*Cylisticus convexus*, *Armadillidium vulgare*, *Porcellionides pruinosus*, *Platyarthrus hoffmannseggii*, the ventral wall is the thinner, and is normally adapted for respiration. We shall see that some species use this ventral surface more than others, but there is not the slightest doubt but that Stoller is incorrect in his description. A glance at Figs. 4, 25, 53, 57, 59, and 69 will show this.

*The Endopodite:* It has already been pointed out that there are only three pairs of endopodites. The 3rd abdominal exopodite is the first to have a corresponding endopodite. This latter is slightly smaller in area than its exopodite, but its structure is in marked contrast, as can be seen in figures 3, 4, and 5. The chitinous cuticle is very thin, and the epithelium is, on the contrary, very thick, and the whole appendage is spongy. There is one peculiarity which I have not noticed in the endopodite of any other woodlouse, and that is a lobe which is seen attached to the inner distal corner of the appendage. The blood cavity of the endopodite is continuous with that of this lobe. In Fig. 3 I have attempted to show the nuclei and the large epithelial cells as they are seen after the endopodite has been treated with methylene blue. In Fig. 5 a portion of an endopodite is shown as seen in cross section. The large nuclei are very clear, but the cell boundaries cannot be seen. There are very few pillars running from the epithelium of one wall to that of the other. They are narrow pillars, and as one follows them into the epithelium radiating fibres can be seen. The blood cavity is very variable in size, in some sections the epithelial linings are closely opposed, in others they are widely separated. These observations support Kimus's suggestion that the function of the pillars is partly to assist the flow of blood through the appendages.

The pillars are very similar to the type found in the endopodites of *Asellus aquaticus*, and to which Kimus has devoted so much attention. The chief point to note here is that these pillars are not complete cells, but formed of the fused protuberances which are carried by the large epithelial cells. Kimus in summarising the kinds of pillars found says of this kind—

“Enfin, le pilier formé par l'union, à travers la cavité “branchiale, de protubérances appartenant à deux larges “cellules épithéliales, qui en possèdent plusieurs semblables.”

The pillars of the exopodite are quite different. They are formed of the union of two or more cells. The cells of

one wall unite with the cells of the opposite wall. The question of these pillars is discussed in the summary.

2. *Oniscus asellus*, Linn.

Pl. XI, figs. 7-16.

The general arrangement and number of the abdominal appendages are the same as in *Trichoniscus pusillus*. Looking at these appendages *in situ*, a peculiar feature is at once seen. The outer border of each exopodite has quite a different appearance from the rest of the exopodite. This outer border appears as a silvery white segment, rather less than a semi-circle in shape and occupying from one-fifth to a quarter of the area of the whole exopodite. (Pl. XI, fig. 7.) This unusual appearance attracted my notice, and I began to study it by observations on living specimens and by means of sections. When watching the breathing action of *Oniscus* under a low power of the microscope, it was clear that these border organs had bubbles of air underneath them, and that the silvery appearance was due to this. With a little patience one could get the air replaced by water, and then the silvery appearance disappeared. By flooding the *Oniscus* with weak alcohol, the air was dislodged, and the alcohol could be replaced by water before any permanent injury was done. In this way I satisfied myself that the silvery appearance was entirely due to the air imprisoned under the corrugated crescentic lobes. I mention this here because below I shall refer to Stoller's work which later caused me to review the whole matter.

This special part is very thin and, having its outer or ventral wall flush with that of the ordinary part, there is a considerable space between its inner or dorsal wall, and the underlying exopodite or the body wall. This is the air or lung cavity, and the air is renewed by the raising and lowering of the exopodites as well as by the flexing of the abdomen and other movements caused by locomotion.

Besides this special arrangement, designed, as we shall see, for more efficient respiration of air, *Oniscus* has exopodites and endopodites which, similar to those already described in *Trichoniscus*, are adapted for breathing of moist air. The endopodites, although not so wet as those of *Trichoniscus*, are yet obviously meant for the same kind of respiration, and the habitat confirms this conclusion: for *Oniscus* is often found along with *Trichoniscus* in very damp situations; but the presence of other breathing organs en-



ables it to exist in places which would be too dry for *Trichoniscus*. I shall refer to this in detail later.

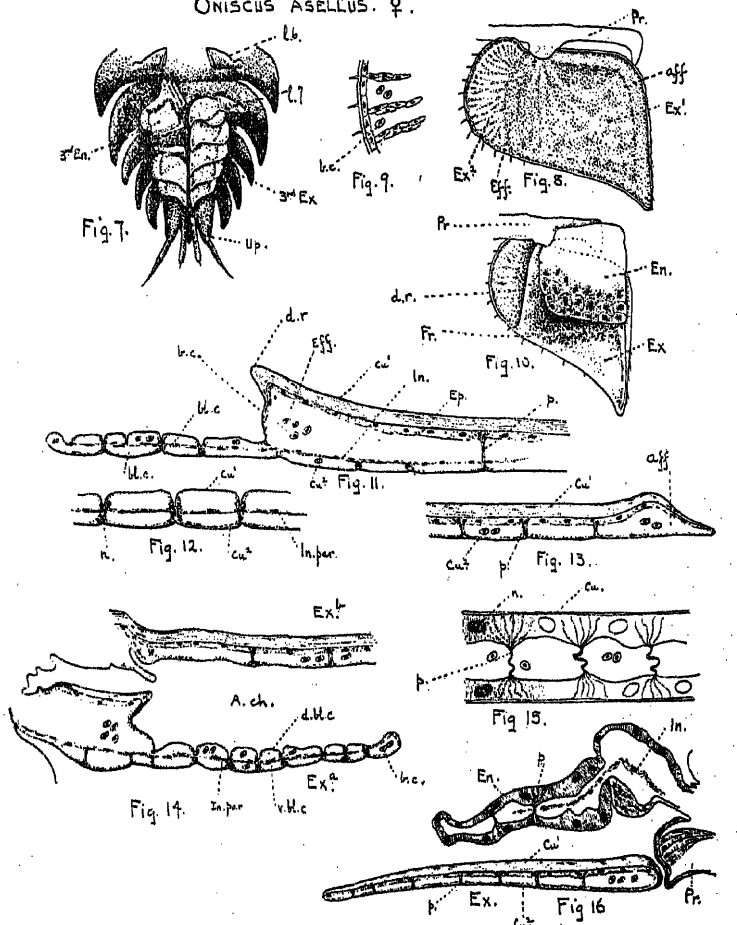
*The 3rd Abdominal Appendage:* Fig. 8 gives a general view of the appendage from the ventral side, and in Fig. 7 the 3rd exopodite on the right side has been turned back to show its corresponding endopodite. Reference to these drawings will save much description. The ordinary part of the exopodite and the endopodite exhibit much the same structure as those appendages in *Trichoniscus*, although the larger size makes it easier to examine the histology in detail. Reference to Figs. 11, 15, 16, especially to Fig. 16, which is a longitudinal section passing through an exopodite and its endopodite in such a way as to pass through the ordinary part of the exopodite, will show the chief points of interest.

*The Exopodite:* In the main part of this plate the inner or dorsal wall has a very thick cuticle, carrying still further the arrangement we have noted in *Trichoniscus*, and to which we have already referred at some length. The outer or ventral wall is very thin, and points to the use of the outer face of the exopodite as a valuable breathing organ, for not only is the chitinous cuticle very thin, but the epithelial layer is also very much reduced, so much so that in places it is difficult to make out. Thus the blood which flows through the appendage is brought into close relationship with the air outside, and the necessary interchange is possible.

The pillars are more frequent here than in *Trichoniscus*. They resemble the simpler pillars found in *Asellus*, described by Kimus in his memoir. At the base of the appendage the third tissue, the intermediary tissue, can be seen, pushing a little way into the appendage acting as a partition to direct the flow of blood and to prevent the blood staying in the proximal part of the appendage. This tissue, consisting of elongated stringy cells with prominent nuclei, is seen in sections, and can also be seen in the appendage after treatment with methylene blue, and examined as a flat object. In the special part of the exopodite, this tissue becomes a very thin threadlike partition, sometimes double, continuous with a similar partition in the proximal part of the appendage, especially in the part abutting on the special part. This partition serves to divide the internal blood cavity into an upper and a lower cavity.

The structure of this special part of the exopodite must be dealt with in some detail, for it is here that I find myself in serious disagreement with Stoller. After reading his

ONISCUS ASELLUS. ♀.



*Oniscus asellus* ♀.

REV. ed.



account I repeated my own experiments and sectionised the appendages again, and also tried the experiments suggested by Stoller. I will first of all give a detailed description of this part as it is seen by me, and then give Stoller's view, pointing out where I think he is in error.

The figures make clear the general structure. We notice that the exopodite as it approached the outer border where this special segment is situated becomes very much thicker, and then suddenly narrows to less than one-third its thickness; the dorsal wall is the one that alters, the ventral wall of the special part and that of the rest of the exopodite are flush with one another. Besides the change in levels the inner or dorsal wall changes in the thickness of the chitinous cuticle. In the ordinary part of the exopodite it is very thick, in the special part it is exceedingly thin, the thinnest cuticle found anywhere in these appendages. The outer or ventral layer of cuticle is very thin, but decidedly thicker than this on the inner surface of the special part. This points to the fact that the inner surface is of more importance from a respiratory point of view. Both surfaces are thrown into corrugations, but these are much deeper on the inner surface.

Turning now to the internal structure. In all sections, transverse or longitudinal, a partition is seen running through about mid-way between the two faces, but the deeper corrugations of the inner or dorsal surface make the cavities on that side rather larger.

This partition consists of elongated threadlike cells with elongated nuclei. The partition in some places is double with a very narrow space between the two threads, but in other places it appears as a single partition. This partition, the intermediary tissue, is continued into the ordinary part of the exopodite for a greater or lesser distance. Near the proximal portion of the exopodite this partition can be traced into the protopodite, but in the distal part it can be traced but a short way.

The internal cavities are interrupted by the pillars which pass from one face to the other. It is usually only at the base of these pillar cells that any trace of the epithelial lining can be made out. This lining is extremely thin. The pillars are of a somewhat different nature here in that they are grouped together into bands. This arrangement, together with the intermediary tissue, divides the cavity into two sets of radial passages, one set of passages on each side of the partition. This can be seen in a surface view, and an

attempt to show the radial arrangement of pillars is seen in Figs. 8 and 9. If a living specimen is examined under a low power, it is easy to observe the course of the blood flowing through these radial passages. The blood enters the appendage at its place of articulation, which is near the outer border. The blood stream divides, some of the blood going to the exopodite in the ordinary way passing down the afferent canal along the inner border and working its way across the appendage into the efferent canal, which is the boundary between the two parts of the exopodite, and, by this, out of the appendage: other blood takes a different course, it goes to the special part. The transparent character of this special part makes it comparatively easy to observe the circulation. It is best to remove the last pair of legs, and then invert the creature in a watchglass of water, and rest a cover glass on the creature to restrain its movements. The blood corpuscles travel through the ventral radial passages (the uppermost ones, as the animal is placed) towards the margin of the special part. The partition is so transparent that it is not visible, but its presence is obvious, for as the corpuscles get to the margin they suddenly fall through, as it were, to the lower chamber, and one can see them travel back, slightly out of focus, in the dorsal radial passages. The partition comes to an end just before the margin is reached, which accounts for the observation above. Thus in *Oniscus* we have, besides the main portion of each exopodite, which is similar in function to the exopodites of *Trichoniscus* with its outer or ventral surface adapted for respiration, a set of special breathing organs developed on the outer border of each exopodite. Enough has been said to show that these are most valuable additions to the respiratory powers of this creature. The blood in the passages is only separated from the air outside by the thinnest of walls, and the constant supply of blood and the repeated change of air supply the requisite conditions for an efficient breathing organ.

The account given above differs in several important points from that furnished by Stoller. It will be best to quote from his treatise the paragraphs with which I am in disagreement.

P. 25—" . . . In *Oniscus* the general cavity of the gill\* "is not a simple cavity as in *Porcellio*, but is separated into "a number of chambers by means of partitions lying parallel "to the walls of the gill.

(\*Gill or outer gill is used for exopodite; inner gill for endopodite.)

"In the general part of the gill there are two of these chambers, an inner or dorsal chamber and an outer or ventral one. They contain blood. Each chamber is bounded above and below by a thin line. It results from this that the cavities of the two chambers are separated by a double wall. This appears as two fine parallel lines between which is a very narrow space. Lying in this space and occurring at frequent intervals are elongated nuclei. The outer walls of each chamber lie immediately within the hypodermic (epithelial) layers on the respective dorsal and ventral sides of the gill. The outer walls have nuclei, but they occur at widely separated intervals. The hypodermic pillars cross the blood chambers. Where they occur the walls of the chambers curve round them, forming sheaths. Thus the cavities containing blood are everywhere separated from the hypoderm by a boundary wall."

Here are several inaccuracies:—The main portion of the exopodite is certainly a simple cavity crossed by pillars lined by epithelium, thicker on the dorsal than on the ventral side (Fig. 16). In the proximal part of the exopodite and in neighbourhood of the special part this thin partition is present, but not in every part of the exopodite. The nature of this partition; its simplicity in structure to the tissue in the body cavity; its presence in the protopodite and in the proximal portion of the appendage as a blood directing tissue; its presence in the basal part of the endopodite as well; and the fact that a similar tissue is found in *Asellus* and other aquatic isopods are points with which Stoller does not seem familiar. Then he is mistaken when he mentions that the blood cavities have definite boundary walls, that is of cellular structure, other than the epithelial lining and in some cases the intermediary tissue. He, himself, is evidently in doubt as to this, for in a footnote on page 14, added after the treatise was written, he leaves the question undecided. The footnote is meant to qualify the following statement:—

"The blood cavity occupies the whole space within the hypodermic layer, and is bounded by a very thin wall lying contiguous to the hypoderm and conforming to its irregularities. In this wall at long intervals lie elongated nuclei. I infer from the relations of this wall that it is of mesodermic origin." (Stoller.)

In the footnote he refers to the work of Leichmann, who has described the brood pouch lamellæ of *Asellus aquaticus*,

and who found them homologous in structure to the branchiæ, with a simple blood cavity bounded by epithelium. The inner surface of this has a very thin cuticle. Kimus describing the exopodite of *Asellus aquaticus* says:—

“Rappelons que les parois des cavités sanguines sont formées dans la plus grande partie de leur surface, par les deux lamelles épithéliales tapissées intérieurement d’une mince cuticule.”

This very thin cuticle is more evident in some species, e.g., *Porcellio scaber*, and it is this that Stoller has taken to be a definite cellular layer of mesoblastic origin. This mistake runs all through his treatise, his figures too are incorrect in this particular, but perhaps the most serious of the errors into which he has fallen has reference to the minute anatomy of the special part of the exopodite; serious because it has found its way into such a textbook as “A Treatise on Zoology,” Part VII.

He divides the internal cavity of this part into five separate chambers, one below the other, three of these are blood chambers and two are air chambers.

He states (pp. 26 and 27):—“The dorsal and ventral blood chambers of the general part of the gill are continued into the special part of the gill. But in the special part there is present, in addition, a third blood-chamber, which lies between the other two. This middle chamber is formed by the forking of the partition separating the dorsal and ventral chambers in the general part. Each branch of the fork retains the structure of the main partition; that is to say, consists of a double wall, with nuclei lying in the narrow intervening space. While the dorsal and ventral chambers are thus separated along their lateral faces they communicate with each other in certain places at the margin of the gill.”

Then follows a description of the possible communications between the dorsal and ventral chambers, and this so-called middle chamber, which I need not quote. He then proceeds:—

“In addition to the three blood-chambers in the special part of the gill there are other chambers which contain air. These are two in number, situated one on the dorsal and one on the ventral side of the gill. The dorsal air-chamber is bounded outwards by the wall of the gill and inwards by the outer wall of the dorsal blood-chamber.

"The ventral air-chamber has corresponding relations. In other words, in the special part of the gill there is a space between the general wall of the gill (composed of chitine and hypoderm) and the boundary wall of the blood-cavity, and this space contains air. This space does not communicate by any opening with the outside of the gill."

Stoller supports these observations by a number of experiments:—

"As has already been stated, when an animal is placed in water the appearance of air in the gills passes away. This observation led to a number of experiments, the chief purpose of which was to gain evidence, in addition to the evidence derived from direct inspection and from the study of the structure of the gill, that air is normally present in the chambers.

1. "An animal was placed in water until the appearance of air in the gills had passed away. It was then killed, and the tissues fixed by hot 33 per cent. alcohol. In sections of the gills prepared from this specimen the air-chambers did not appear empty (as usual), but contained blood without corpuscles, that is, blood plasma (appearing as granulated matter).

"This experiment, having indicated that under the conditions imposed the air was replaced in part, at least, by plasma of blood, we next sought to modify the experiment in order to ascertain whether the presence of blood in the chambers was due entirely to the conditions being artificial.

2. "The preceding experiment was repeated, excepting that the animal was placed in normal salt solution instead of water. The result was that the chambers contained blood plasma, but perhaps less in quantity than in the previous case.

"In this case the two fluids were of approximately equal densities and, it may be inferred, tended to replace the air in equal measure. Allowance must be made, however, for the greater thinness of the wall bounding the blood-chamber than the outer chitinous wall.

3. "The experiment was repeated, using a concentrated salt solution. The result was that the chambers appeared as empty or nearly so, little blood plasma having entered them.



"In this case it would appear that the more concentrated fluid replaced, in the main, the air. In all three cases the results became intelligible on the supposition that the chambers contain air. Thus, these experiments warrant the inference that the chambers normally contain air and not blood." (Stoller.)

Now let me take some of the points raised in the above excerpt—

I do not agree with the description of the partition in the special part. In most sections the partition seems to me to be a single structure composed of two closely applied very thin strands containing elongated nuclei. In some sections the two strands are rather more separated than in others, but I cannot find anything which can be called a middle chamber. The partition here does not differ materially from the partition in the ordinary part, indeed the two partitions are continuous. I have failed absolutely to find the two air-chambers either by surface observation or by sections or by the experiments suggested by Stoller.

In the paragraph from his treatise quoted above, he describes these chambers as being bounded by the epithelium of the outer wall on one side and the wall of the blood cavity on the other. We have already seen that he is in error in describing a definite boundary wall to the blood cavities, and this initial mistake may have led him into the further error of finding air within the appendage. Certainly there is no wall between his so-called air-cavity and the blood cavity: it was not surprising, therefore, to find blood in these cavities.

I have tried every way I could devise to test the question, but have failed to find any air inside the appendage, and I feel convinced that his observations are incorrect, and that the internal cavity of the special part of the exopodite is simply divided into dorsal and ventral blood chambers. In all my sections I have found blood corpuscles in these chambers. Possibly the idea arose after looking at a section in which the protoplasmic lining had contracted leaving a space between it and the chitinous cuticle. This does take place—due, I suspect, to a too rapid method of dehydration or faulty fixation—and this appearance would certainly result after the use of salt solution.

Really a few minutes' observation of a living creature submerged in water and so arranged that the ventral surface of the abdomen can be viewed in a good light would convince anyone that there is no air inside the walls of this

special part, but only outside. The following simple observation could be made as well. Take off any one of the exopodites from a living specimen, dip it into alcohol to remove the surface air which clings to the corrugated surfaces, and mount it in water. This need not take more than 30 seconds at the most. The special part of the exopodite is quite transparent, there is no trace of air when seen by transmitted or reflected light. Now, if there were air-chambers, as Stoller suggests, it would have been impossible for the air and water or air and alcohol to have interchanged so rapidly, especially as Stoller agrees there are no openings, and that any interchange must take place by diffusion.

Having convinced myself that Stoller is wrong in his account of these air-cavities, there is no need to follow him further, and point out the errors in his account of their physiological function, for it is based upon error.

Although claiming for these special breathing organs a simpler structure, they are still very wonderful adaptations and illustrate another method whereby gill plates can be used for air-breathing. It is interesting to find these adaptations and to compare them with similar contrivances in other members of the *Arthropoda*. It has seemed to me that the lung books of Spiders may have much in common with the branchial plates of land Isopods.

Before leaving the question of the exopodites, I want to point out a peculiarity associated with the last pair of plate-like abdominal exopodites (that is of the 5th abdominal appendage). The under or dorsal surface of one of these appendages is shown in Fig. 10. There is a curious arrangement of long spines or hairs, which occur in radiating groups in a special band across the exopodite. The arrangement suggests a cheval-de-frise, especially as it occupies the place, just posterior to the endopodite, where protection might be necessary. It is difficult to be sure as to the function of this formidable array of hairs. Protection from enemies or from the "excreta" discharged from the anus, which is close by, do not seem sufficient, and their absence in *Trichoniscus* is against these uses. The only suggestion which occurs to me as likely is the possible use in preventing the drying up of the film of water which covers the endopodites, seeing that the last pair are more exposed when the plates are lifted and when the end of the abdomen is flexed.

*The Endopodite:* The endopodites of *Oniscus* are smaller in proportion to their exopodites in surface area than those

of *Trichoniscus*. This is possibly due to the fact that the exopodites have a greater respiratory importance in the former species. Figs. 10, 15, and 16 will give a good idea of its shape and structure. It is little more than a squarish thick walled bag, the cavity is the blood cavity, and it is crossed by pillars. There is little to add to the description already given for *Trichoniscus*, except to note the larger size of the pillars and the fact that they are more numerous. The pillars are of the same character as described in the case of *Trichoniscus*.

3. *Philoscia muscorum* (Scop.).

Pl. XII., figs. 17, 18.

4. *Philoscia couchii* (Kinahan).

Pl. XII., figs. 19, 20.

The general arrangement and structure of the respiratory appendages of *Philoscia muscorum*, are the same as in *Oniscus*. Fig. 17 shows a ventral view of the abdomen of a female, and Fig. 18 the 3rd abdominal appendage seen from the ventral aspect. These figures serve to indicate its likeness in details to *Oniscus*. The exopodite with its special respiratory organ, and the endopodite are so similar in structure and function to those already described for *Oniscus* that there will be no need to repeat any part of it here.

The exopodite of the 5th abdominal appendage also shows a similar cheval-de-frise on the dorsal surface.

*Philoscia couchii*: The general arrangement and structure of the respiratory plates are similar to those of *P. muscorum*; but the special respiratory organs of the exopodites are poorly developed. Fig. 19 shows a ventral view of the abdomen, and in this figure and in Fig. 20 the character of the exopodite can be seen. The endopodites seem rather larger in this species. The structure of the special border organ, although much smaller in size, is identical with that of *Oniscus*, or *P. muscorum*.

I can find no trace of the rows of special hairs—the cheval-de-frise on the exopodite of the 5th abdominal appendage. This fact seems to support the suggestion made that they have some function in connection with respiration, in protecting the cavity in which the last pair of endopodites are found. The very damp habitat of this species making such protection unnecessary.





5. *Porcellio scaber*, Latr.

Pl. XII., figs. 21-25; Pl. XIII., figs. 26-40.

Fig. 21 gives a ventral view of the abdomen, and from this figure and the longitudinal section drawn in Fig. 25 it will be seen that, apart from the white patches of the first two pairs of exopodites, the general arrangement is similar to that described in the other woodlice.

We have to deal here with two distinct methods of respiration. There is the method similar to that described in *Trichoniscus*, using the endopodites and exopodites of the 3rd, 4th, and 5th abdominal appendages, and then the special method which is developed in connection with the air-trees or air-sponges carried by the exopodites of the 1st and 2nd abdominal appendages.

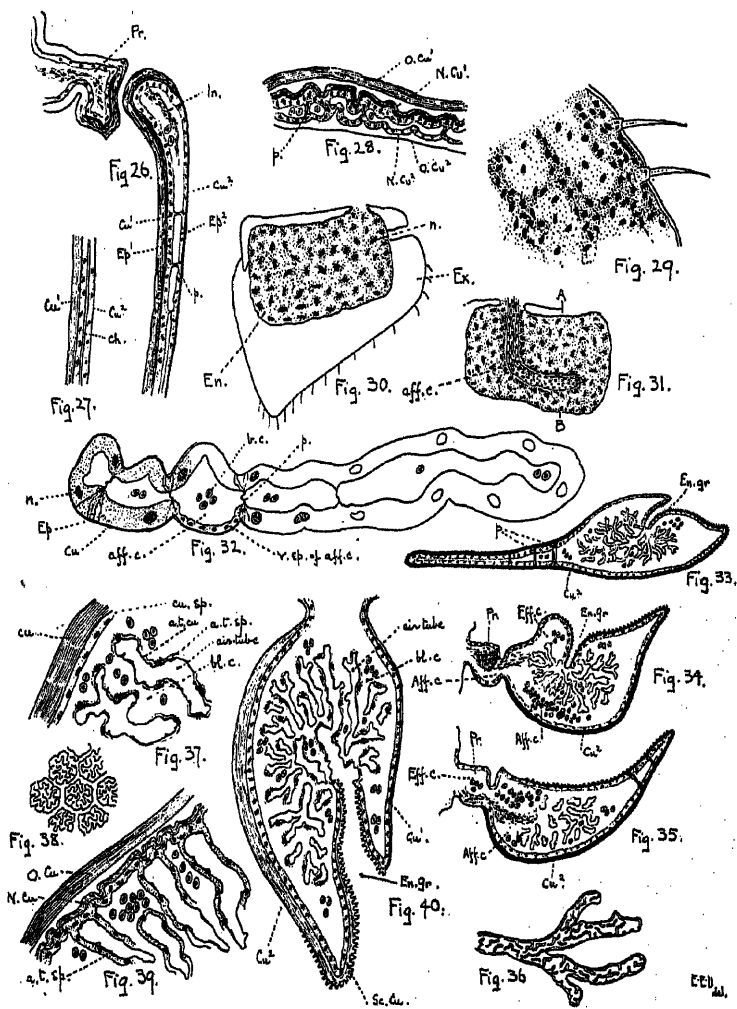
It will be best to examine the more normal method first and for this purpose we will take the 3rd abdominal appendage. The general shape of exopodite and endopodite can be seen from Figs. 24, 30, 31, so that a description need not be given. At first sight there seems but little difference from the structure which we look for in these parts, but both exopodite and endopodite present peculiar features. When the exopodite is examined under the microscope, either in the living condition or after treatment with methylene blue, it is evident that the usual passages for the blood, the afferent along the inward border, the efferent along the outward border, and others traversing the central part, are not present. The exopodite seems to be much more of a regular mass of cells, and only in the proximal part can one make out any sign of blood spaces. These are few, and do not extend far into the exopodite. Fig. 29 gives some idea of these blood spaces seen from the ventral surface. The epithelium appears to be gathered into partitions dividing the cavity into a number of small galleries. Some observations upon the living creature will now be described. I have found it best to use a hollow-ground slide—varying the size of the hollow to suit the size of the woodlouse—and using a rather thicker cover-glass held down by two pellets of paraffin wax. The wax can be melted by a mounted needle, and the height of the cover-glass adjusted so as to restrain the creature with its ventral surface uppermost. It is always best to remove carefully the last two pairs of legs, for they are apt to obscure the abdominal plates.

The breathing action of the exopodites is very evident, and even in such a "dry" species as this, there is a film of water covering the endopodites and the dorsal surface of their exopodites. The film can be seen alternately retreating and advancing as the exopodites are raised and lowered. If working with a table lamp the heat from this is sufficient to cause some evaporation of this water, and one can see the air gradually working its way under the exopodites, as the water recedes, until there is a large bubble of air in the space between the exopodite and the ventral wall of the next exopodite. This air bubble expands and contracts as the exopodites move. When the air has gained access to the space under the exopodites, the silvery appearance of the exopodite resembles very closely the special segment of the exopodites of *Oniscus*, to which attention has already been directed, and confirms the point that their appearance is due to the air imprisoned under those special edges.

The creature in this position is useful for showing the circulation of the blood in the exopodites, and it is usually advisable to run in water under the cover-glass so as to submerge the animal and get rid of the surface reflections. It is interesting in passing to note that when it is submerged, the movement of the exopodites is much more marked. They become widely separated at each movement, no doubt owing to the ease with which they can be moved in the water, and not because of any increase in muscular action, for if the water is drained away, the amplitude of the movements is once more reduced to the normal. It is important to remember that air can gain access more easily than water, and the slight movement of the exopodites sufficient for the purpose of the necessary exchange, will also prevent the desiccation of the endopodites. The circulation of blood in the first two pairs of exopodites will be referred to later. We are concerned with the exopodite of the 3rd and the next two abdominal appendages. I have watched both males and females for hours, but have failed to detect any circulation in the distal region of the exopodites. In the proximal region now and again a blood corpuscle could be seen threading its way from one side to the other, but there is here nothing comparable to the circulation which can be seen in *Trichoniscus* or *Oniscus*.

In the sections examined very few blood corpuscles have been found in the exopodites, indeed the epithelial linings of the two faces are so closely applied, save in the proximal region, that the large corpuscles could not pass through the

Porcellio scaber ♀.



Porcellio scaber ♀.



1. The first part of the paper is devoted to a general discussion of the problem of the existence of a solution of the system of equations

$$\frac{dx}{dt} = f(x, y, z), \quad \frac{dy}{dt} = g(x, y, z), \quad \frac{dz}{dt} = h(x, y, z),$$

where  $f, g, h$  are continuous functions of  $x, y, z$  and satisfy certain conditions.

2. In the second part we consider the case when the functions  $f, g, h$  are linear in  $x, y, z$ .

3. The third part is devoted to the study of the stability of the solutions of the system.

4. In the fourth part we consider the case when the functions  $f, g, h$  are periodic in  $t$ .

5. The fifth part is devoted to the study of the asymptotic behavior of the solutions of the system.

6. In the sixth part we consider the case when the functions  $f, g, h$  are analytic in  $x, y, z$ .

7. The seventh part is devoted to the study of the bifurcation of the solutions of the system.

8. In the eighth part we consider the case when the functions  $f, g, h$  are piecewise continuous in  $t$ .

9. The ninth part is devoted to the study of the qualitative properties of the solutions of the system.

10. In the tenth part we consider the case when the functions  $f, g, h$  are bounded in  $x, y, z$ .

11. The eleventh part is devoted to the study of the global properties of the solutions of the system.

12. In the twelfth part we consider the case when the functions  $f, g, h$  are continuous in  $t$  and piecewise continuous in  $x, y, z$ .

13. The thirteenth part is devoted to the study of the stability of the solutions of the system.

cavity. It is only in the proximal region that there is a normal blood cavity. However, at one special period there is a considerable amount of blood found in the exopodites, and this is when a new chitinous cuticle is being secreted by the epithelial layer. I was fortunate enough to get one or two specimens in this condition, and the sections through the abdominal appendages have been most instructive. If Figs. 26, 27, and 28 are studied, these points are still further illustrated. Fig. 26 shows the protopodite and the proximal one-third of the exopodite in longitudinal section. The epithelium is shown in too dense and definite a form for a normal exopodite. It is like that when the new cuticle is formed, and then the protoplasm becomes vacuolated and stringy, and the exopodite appears in section like Fig. 27. The epithelium has, however, a very definite inner wall, and appears rather like an extremely thin layer of chitin. This persists, and seems especially distinct in *Porcellio*. It is probably this inner boundary of the epithelial cells which led Stoller astray, and induced him to describe it as a distinct layer of elongated cells forming the wall to the blood cavity. Also, there are little irregularities which might be taken for tiny nuclei by a casual observer, but there are no nuclei there, and the whole structure is very clear when exopodites in different conditions are examined. Fig. 28 gives the appearance when a new cuticle is being formed beneath the old one, and it is at such a time as this that blood corpuscles are found in the internal cavity. It is by a comparison of such an exopodite with one during the intermoult period that the real meaning of this definite boundary is understood. In the distal part of the exopodite the two epithelial layers come so near to one another that the two boundary lines give the appearance, under the low power, of a median line dividing the exopodite into two, but this is not really so. (Fig. 27.)

Both the chitinous cuticle and the epithelium are thicker on the dorsal or inner side. This conforms with the general rule for woodlice, and Stoller's mistake with regard to this has already been referred to. There is no need to repeat his words here.

In the proximal region, especially in the part near to protopodite, a little intermediary tissue can be seen. (Fig. 26.) It blocks up what would otherwise be a large cavity, and so retards the flow of blood both in the protopodite and the exopodite. Another unusual feature is the poor development of the pillars. There are very few pillars, and those

that are present appear to be a simple fusion of the epithelial cells of each face, and nothing of the definite structure, which we have referred to in the other forms, is visible here. They cannot be traced from cuticle to cuticle, and are of the simplest form; indeed they appear to be degenerate, for they are much more evident in a specimen which is forming a new cuticle. (Fig. 28.)

This exopodite, as well as those of the next two appendages, was probably useful for respiratory purposes at one time. The very thin chitinous cuticle on the ventral surface points to this, but in course of time when the exopodites of the first two abdominal appendages developed the efficient air-tree organs, it was more economical to concentrate the blood supply in these special organs; consequently the respiratory function of the 3rd, 4th, and 5th pairs of exopodites, became less important, and degeneracy of pillars and epithelium would naturally follow.

The inner or dorsal surface of the 5th pair of exopodites has the curved rows of special hairs, similar to those described under *Oniscus asellus*. Also on the ventral surface of the abdomen at a place covered by this part of the exopodite, there are found large backwardly curved setæ. (Fig. 25.)

*The Endopodite:* The endopodite is, except in one important particular, similar to that described under *Trichoniscus* and *Oniscus*. It is a flattish bag with thick spongy walls, which are composed of a very thin chitinous cuticle, and a thick epithelial layer containing large nuclei. A few pillars join the cells of the two faces. In these things it is typical. The protopodites which carry the exopodites and endopodites stand out well from the ventral surface, and thus form between adjacent protopodites and exopodites a series of pockets in which the endopodites lie. This arrangement can be seen in Fig. 25, but the exopodites and endopodites in that drawing are not in their natural positions for the killing and subsequent operations incident to sectioning cause the exopodites to gape. In life the exopodites are found resting on one another, and this will close the pocket in which the endopodite rests.

It is usual to find that a mass of intermediary tissue directs the course of the blood as it enters the endopodite from the protopodite, in such a way that the blood will pass down the inward border and out along the outer border. Here there is something quite different.

When the endopodite is examined as a flat object under the microscope, especially after treatment with methylene blue, a curious curved finger-like mark is seen bent to form the letter L. The mark runs from the place of articulation directly backward and then turns towards the inner border. At first sight this had the appearance of a process of cells pushed into the cavity of the endopodite, but neither dissection nor sectioning showed any intermediary tissue either in the proximal or distal region of the endopodite. The sections, however, did show that this appearance was due to a tube with a special wall. If the endopodite is examined with the dorsal surface uppermost, the wall in the region of the tube is in no way different from that of the rest of the face; but if the ventral surface is examined, the thick, large-nucleated cells of the endopoditic epithelium give place to small thin cells with small nuclei in the part where this special tube is situated. This can be seen by altering the focus and bringing into view alternately the dorsal and ventral walls of this tube. Thus, there is a wide tube or channel running from the protopodite into the middle of the endopodite, and this channel is bounded by the ordinary wall on the dorsal side, by a special layer of small cells on the ventral side and laterally by the more or less opposed walls of the epithelial cells with frequent pillars joining the two sides together. The relations of this channel have been followed through a series of sections, and reference to Figs. 31 and 32 will suffice to make clear this unusual feature. This channel is an afferent blood canal bringing blood into the middle of the appendage, and is an effective way of regulating the flow of blood. Stoller gives no hint of this structure in his reference to the endopodite.

*The Exopodites of the 1st and 2nd Abdominal Appendages:* We must now consider in detail the interesting breathing organs which are found in the first two pairs of abdominal appendages. They appear as whitish marks to the naked eye, and as air-trees or air-sponges when examined under the microscope. They are an attempt at a more satisfactory method of breathing, and aim at bringing the air and the blood into closer relationship by means of invaginations of the outer wall.

One is reminded at once of the tracheal tubes of insects, but here we are faced with an independent and very much less perfect method and one, furthermore, which is very much restricted; for the air only enters into a part of four abdominal plates, whereas in insects the tracheal tubes ramify

throughout the body. The blood in woodlice is therefore of the more importance as a carrying agent of oxygen from these special breathing organs to the rest of the body. These air-tree organs are found in both male and female, and are essentially the same, so that a description of the female exopodites will be given.

Figs. 22 and 23 give a general appearance of these air-tree organs as seen from both the ventral and dorsal aspects. Fig. 22 represents one of the first abdominal exopodites, ventral aspect; Fig. 23 one of the second exopodites, dorsal aspect.

Only a brief account of the general structure of these organs, sufficient to enable anyone to follow the detailed description, is necessary. The cavity of the exopodite is invaded by a tree-like invagination of the wall, and this causes a wide separation of the dorsal and ventral surfaces of the exopodite. The entrance to the air-tree is on the inner or dorsal surface, a little way from the outer posterior border, and the actual entrance is situated in a transverse groove, the opening of which points backwards. The place of the actual opening into the air-tree is indicated by a notch in the ventral posterior border. This notch is very conspicuous in the exopodites of the 2nd abdominal appendage (Fig. 23).

The chitinous cuticle, which is more or less sculptured in all parts of the body, has a very characteristic pattern in the region of this groove. Fairly deep furrows divide up the thickened chitin into hexagonal areas which carry a maze-like arrangement of narrow ridges. Fig. 38 shows a few of the hexagonal patches seen from above. In section the chitin has the appearance of flat-ended processes carrying hairs (Fig. 40). The limits of this specially sculptured chitin are important. Starting from the dorsal edge of the groove, it covers both the sides of the groove and extends to the posterior ventral border and round on to the ventral surface for a short distance. Fig. 40 shows the distribution as seen in a section taken along the line EF in Fig. 22.

The air-tree occupies rather less than half the area of the exopodite. The remaining part is more or less typical in structure, except that, as compared with the exopodites of the 3rd abdominal appendage, there are better pillars and a wider blood cavity. When a living specimen is under observation, it is easy to see that blood corpuscles do penetrate into the normal part of the exopodite, going some little way before sweeping round towards the air-tree, the destination

of the blood. The pillars are interesting because of their degenerate condition in the other exopodites. Large, well-defined pillars, running from cuticle to cuticle, mark the place of transition from the swollen, air-tree part and the narrow, normal part; other smaller, yet very well defined, pillars, are scattered near by. Fig. 33 represents a transverse section through such an exopodite as is shown in Fig. 23, the line of section being along the line AB.

It should be noted that the exopodites of the first and second abdominal appendages have thicker chitinous cuticle on the ventral than on the dorsal surface. This exception to the general rule (Fig. 40) has to do with the method of changing the air in the air-trees. This will be discussed below. It has already been pointed out that the amount of blood passing through the exopodites of the 3rd, 4th, and 5th abdominal appendages is very much less than the amount passing through the same exopodites in *Oniscus* and *Trichoniscus*. When, however, we examine the exopodites of the 1st and 2nd abdominal segments in *Porcellio scaber*, a very different state of things is found. In these exopodites there is a good and constant circulation. The blood enters the exopodite by a definite passage or channel from the protopodite on the ventral side of the appendage, and finds its way through the meshwork of air-tubes to the dorsal and posterior side, where, collecting in a large blood space which runs along anterior to the large groove, it passes out by another definite channel into the protopodite and so back to the pericardium and heart. The intermediary tissue or tissue of the body cavity is the limiting tissue of these afferent and efferent blood channels. One can see the blood rushing into the exopodite, and the major part of it at once becoming entangled as it were in the maze of blood passages caused by the branches of the air-tree; some of it, however, as we have noted, travels out into the flatter part and then works back to the air-tree, entering the maze of passages at the side. The blood corpuscles slowly thread their way among the air-tubes until lost to sight in the depths of the tree.

By examining serial sections taken across such an exopodite further details can be made out, and in Figs. 34 and 35 two out of such a series are given. Fig. 34 representing a section taken along the line AB in Fig. 22 shows the afferent channel on the ventral side, leading into a large blood space or sinus from which the blood will be distributed to the air-tree organ. The dorsal sinus (eff. c.) is also shown. In Fig. 34 representing a section taken along the line CD, nearer

the outer border, we see the end of the dorsal sinus and the efferent channel leading from it out into the protopodite. I have given the circulation in some detail, for Stoller in his account does not deal fully with it. The function of the dorsal sinus or collecting chamber, which is so important in connection with the even passage of the blood through the sponge-like mass, has been misunderstood by Stoller, who also presents what I feel is a mistaken explanation of the special sculptured region of the chitinous cuticle which surrounds this sinus and the entrance to the air-tree. He looks upon these two things, the dorsal blood space and the grooved wall, as furnishing an important subsidiary respiratory organ. It will be best to quote one or two paragraphs from his thesis:—

“That the larger furrows or grooves separating the polygonal areas contain air may be demonstrated by mounting a gill in water, when they are seen to appear white by reflected and dark by transmitted light. If a gill is placed in alcohol before examining, the network does not appear dark under transmitted light. The finer furrows of the polygonal areas do not appear to hold air.” (P. 13.)

“It is evident that the gill of *Porcellio scaber* is a structure adapted to bringing the blood into relation with air. Two different and independent anatomical structures are employed in order to secure a ready exposure of the two media to each other. These are first, the net-work of furrows in the chitine at the exterior of the gill, and second, the unfolded portion of the chitinous wall, forming the internal tree.” (P. 15.)

“Applying these principles (i.e., permeability and strength) we see that in the specially modified portion of the chitinous wall at the exterior of the gill increase of surface and at the same time thinness of wall is secured through the furrowing of the chitine. Furthermore, the furrowed structure is that which in the least degree compatible with the attainment of these two ends detracts from the strength of the wall. The arrangement of the furrows in a net-work is adapted to securing the largest linear extent of grooving, and at the same time the least sacrifice of strength of the wall. The shape of the furrows which as seen in section (Fig. given) is that of an oval with the long axis at right angles to the face of the wall is, I conceive, adapted to a threefold purpose, namely: first, to contain a large amount of air relative to the space oc-

"cupied; second, to retaining this air in the groove (by means of the narrowing of the opening); and third, to reduce to the least extent the strength of the wall (by means of the resistance to fracture secured through the curved surface to the oval).

"The tree, as a mass, is somewhat spherical in shape which secures the most favourable distribution of the branches in the fluid surrounding them. But the sphere is depressed on the basal side of the tree, leaving a space between the base and the grooved area of the wall of the gill. It is evident that this is an adaptation for bringing a relatively large amount of blood into rotation with the air contained both in the grooves and in the basal branches of the tree." (P. 16, Stoller.)

The special sculpturing of the chitin around the entrance to air-trees is to keep them free from the danger of becoming clogged by water. If a specimen, secured in the way already described, so as to exhibit the ventral surface of the abdomen, is flooded with water, it is clear that unlike the rest of the body, the chitin of these special regions of the first two pairs of exopodites, is not easily wetted. It will be remembered that the special sculpturing extends some little distance on the ventral surface, and it is easy to see the air clinging to this part and keeping the water away from the entrance to the air-trees. If one of these exopodites is removed and mounted in water, it is possible to examine it under the high powers of the microscope and to see that there is certainly air retained in the smaller furrows upon the hexagonal areas just as there is air in the wider furrows between the hexagonal areas. Stoller is not correct in thinking that these smaller furrows do not retain air. It is very easy to demonstrate that they do, by exchanging the water for alcohol and watching the effect. With care, the water can be withdrawn and alcohol substituted without disturbing cover-glass or exopodite. As the alcohol begins to flood the exopodite the air is driven out of both the larger and the smaller furrows. It is obvious that air in these smaller furrows would be useless for respiration.

Then again the distribution of this specially sculptured chitin points to a different use from that suggested by Stoller. Not only is it found on both sides of the entrance groove leading into the air-tree, where the chitin is very thin below the larger furrows, but it extends round the posterior and outer edge of the exopodite and on to the ventral surface,



where the chitin is very thick. Then the rest of the dorsal surface, especially the part just anterior to the edge of the groove, is smooth and thin. There is a blood cavity within the appendage at this place, and if the sculpturing aided respiration this seems the very place to have it (cf. Pl. XIII., figs. 34, 35, and 40).

The use of this elaborate sculpturing of the chitin is to prevent water from clogging the entrance to the air-tree, and thus stopping the free current of air so necessary for efficient respiration. It is interesting to remember that aquatic insects exhibit a somewhat similar device for preventing water from entering the spiracles.

The position of these air-tree-holding exopodites so near the ground, and the fact that the other breathing organs, the endopodites, are only functional when coated by a film of water, make some protection essential to the success of the air-trees.

With respect to the minute anatomy of the air-trees I am again in disagreement with Stoller's account. He says, on p. 15:—"The walls of the tubules are thin and show no markings. Lying outside of the chitinous layer is the likewise thin hypodermic layer. Outside of this and closely associated with it is the boundary wall of the blood cavity. Thus, every portion of the wall of the tree is composed of three very thin layers. The hypodermic nuclei occur at frequent intervals." (Stoller.)

There is no need to refer again here to the question of a definite wall to the blood cavities. It has already been shown that this does not exist. There are but two layers separating the blood cavity and the air-tubes, the epithelial (or, to use Stoller's term, hypodermic) layer and its chitinous cuticle. However, as in the other places, this epithelial layer is usually reduced until it appears that only a very thin layer of chitin separates blood and air, but the nuclei of this epithelial layer are prominent, and at certain times the whole layer is very evident. When a new cuticle is being formed beneath the old one, the epithelial layer is seen to best advantage, and Fig. 39 shows a section through a portion of the air-tree of a specimen in this condition. The normal condition of the air-tree in section is shown in Fig. 37. The epithelial layer is much reduced, except the layer which is beneath the surface cuticle.

Further, I do not agree that the chitinous walls of the air-tubes—the branches of the air-tree—are smooth. I

find that the walls of all these air-tubes, both great and small, are thrown into ridges which remind one of the ridges upon the surface of the hexagonal areas on the chitin around the entrance to the air-tree.

In another place in his thesis Stoller, speaking of these air-tubes, says:—"The whole structure appears to be hollow, with smooth thin walls. The appearance of irregular markings on the walls is probably due to shrinkage, consequent upon the passing out of air." (P. 13.)

I have examined a very large number of these air-tubes under every kind of condition, both living and dead, with air inside and without air, as flat objects and in section, and I find that the walls have this distinct pattern of ridges. Fig. 36 shows the appearance when the tubes are full of air; and in the various figures of sections across the air-tubes the same irregularities of the wall are indicated (Figs. 37 and 39).

The presence of this distinct pattern on the chitinous lining of the air-tubes is most interesting in comparison with the structure of the tracheal tubes of insects.

The great problem for solution, to which Stoller makes no contribution, is the effective renewal of air in these air-trees. I believe that this pattern on the walls of the branches of the tree plays a part similar to that played by the spiral thread in the insect's tracheal tubes. *But where does it get the pressure?* There is no internal mechanism. At one time I wondered whether there would be pillars running across the swollen area, but this is not so. The only pillars are found in the more normal parts, and their operations would have little effect upon the air-tree organ. Could there be any other way of bringing pressure to bear upon the exopodites? There is the lowering and raising of the exopodites, the normal isopod breathing action, but as we have seen, this movement is very slight in these land-forms, and in the first two pairs of abdominal appendages, the air-tree exopodites hardly move at all. This does not seem effective. The clue came to me whilst watching a number of *Porcellios* which I had placed in different vessels for experiments in duration of life under different conditions of dryness, and varying amounts of carbonic acid gas, and also in water. When the creatures were in difficulty with their breathing, I noticed that the whole abdomen was alternately raised and lowered in an unusual manner. This was especially evident in a specimen placed in carbonic acid gas. When

the abdomen was raised and extended the exopodites stood well out from the ventral surface, somewhat as they are drawn in the longitudinal section shown in Fig. 25. When the abdomen was lowered and contracted the exopodites were pressed tightly against one another, and the transverse ridge seen in Fig. 25 as a process just anterior to the 1st exopodite, was pressed against the 1st exopodite.

By experimenting with an inverted woodlouse in a glass cell, which allowed a certain play of the abdomen, I was able to confirm the above statement; and by submerging the creature could get evidence of the effect of the pressure upon the air-tree organs. The ventral wall of those exopodites which bear the air-tree organs, is very thick, whilst the dorsal wall is very thin. (Figs. 40, 34, 35.) The attachment to the protopodite is such that any external pressure would cause the exopodites to respond readily to it. Indeed, the shape, the way in which they press against one another, the transverse fold of the ventral wall which abuts on to the ventral surface of the exopodite of the first abdominal appendage, all support the above suggestion that pressure is exerted by flexion of the abdomen.

The next point to consider was the effect of the pressure upon the air-tubes inside. One of the easiest ways of seeing this, is to remove one of these exopodites from a living *Porcellio* and examine it under the high power of microscope. By cotton wool or some such substance, the cover glass can be kept from pressing on to the exopodite, until such pressure is required. When slight pressure is exerted on to the cover glass, the effect can be watched. The air is seen to leave the finer tubes or branches, and then return when the pressure is relaxed. By careful observation it is clear that the character of the wall of the air-tubes in being strengthened in the way already referred to, is responsible for this return to the normal condition. The ridge-like markings on the walls enabled the tubes to spring open again when the pressure is relaxed, and so allow the air to return unobstructed. Without some such arrangement as this, it would be impossible to get the air into these very minute air tubes.

The pressure on the surface walls of the exopodite will be conveyed by the blood in the blood cavities which surround the air-trees, to the larger and smaller air-tube branches of the air-trees. It seems clear that the mechanism for bringing about the exchange of air in the air-tree is external pressure brought to bear upon the exopodites, by the flexion of the abdomen.

It may be that the legs also play some part in bringing pressure to bear on these air-tree-holding plates, for the last two pairs of legs, when the creature is at rest, are carried bent inwards so that the basipodites rest upon these first two pairs of exopodites. When *Porcellio* is disturbed, the creature usually tries to disarm suspicion and to protect itself by an attempt to roll up the body; the legs are all bent inwards and pressed tightly against the ventral body wall, and the body is flexed to such an extent that it often rolls over on to its back. This special flexion of the body will bring considerable pressure upon the first two pairs of abdominal appendages, and although the action is primarily one of defence, it cannot fail to be of use in respiration.

The whole question of the flexion of the body, carried to far greater lengths in *Cylisticus convexus* and in the *Armadillidia*, is of considerable interest and is, I believe, correlated with this new method of respiration. The matter will be discussed when these other genera are under review and when the whole question of respiration is discussed in its relation to the habitat of the various forms, in a further communication.

#### 6. *Cylisticus convexus* (De Geer).

##### Pl. XIV., figs. 41-48.

The arrangement and disposition of the abdominal appendages is similar to that described in the other woodlice, except that the lateral plates of the 3rd, 4th, and 5th abdominal segments bend downwards, so as to make a shallow cup-like cavity in which the abdominal appendages lie. This is shown in Fig. 42. A ventral view of the abdomen is shown in Fig. 41, and the five pairs of air-tree organs are indicated.

*The 3rd Abdominal Appendage:* Fig. 43 gives a ventral view of this appendage. From this the general details of shape and relation of the parts can be determined.

*The Exopodite:* The exopodite is divided into two regions: the normal, thin, plate-like part and the special swollen part containing the air-tree organ. This latter part is towards the outer border of the exopodite and extends over rather less than half the area of the exopodite. The size of this swollen part diminishes somewhat in the 4th and 5th exopodites, but is about the same size in the 1st two pairs of abdominal exopodites.

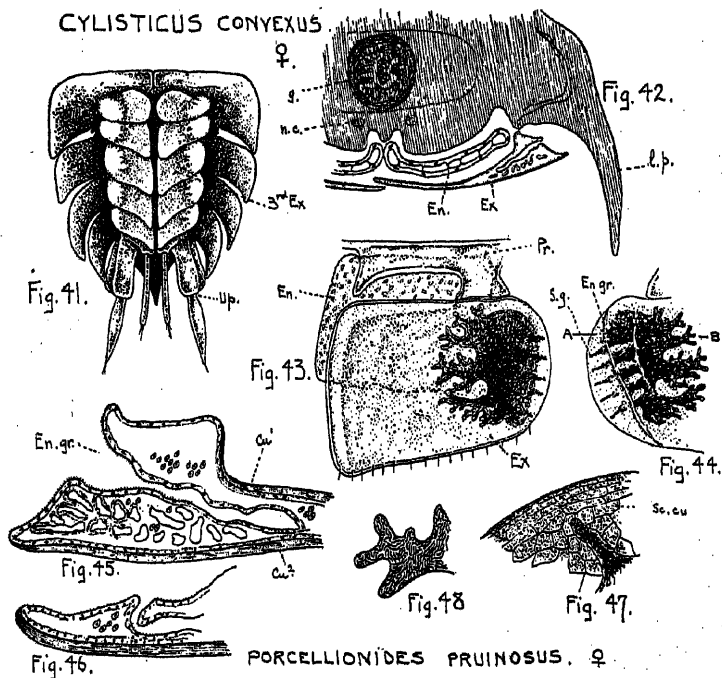
When the living animal is observed under the microscope, it is easy to see that the exopodite of this appendage

has a good blood supply, and is in this respect much more like *Oniscus* than *Porcellio*. There is a constant and a vigorous stream of blood flowing towards and through the air-tree organ much the same way as has already been described for the first two abdominal exopodites of *P. scaber*. The cause of the blood is also very much the same as already described in *Porcellio*, and is much the same in all the abdominal exopodites. The exopodite of this appendage, as well as of the next two pairs, acts as an operculum as well as an additional breathing organ, and it is so arranged that the one function does not interfere with the other. Fig. 42, in which a section through the 3rd abdominal appendage is drawn, shows this very well. The dorsal wall of the exopodite is so arranged that the alteration in levels, between the swollen air-tree part and the normal part, is abrupt. Thus the endopodite is enclosed in a kind of chamber. The openings into the air-tree organs are on the outer border well away from this chamber, which is kept very moist.

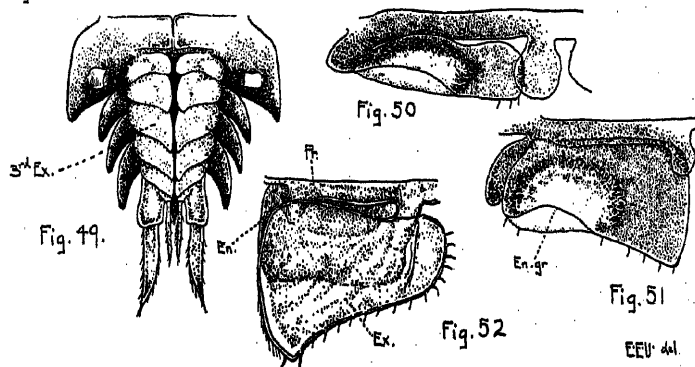
There is no need to give a detailed description of the normal part of the exopodite. It is typical with its chitinous cuticle, epithelial layers, and the pillars transversing the cavity. The dorsal chitinous wall is, in this region, thicker than the ventral one, thus conforming with what has been found to be the general rule in land isopods, but the ventral wall is not very thin, which is what we should expect seeing the respiration will be undertaken by the air-tree organs, and not take place through the ventral wall. Then as the walls approach the region of the air-tree organ, a change takes place, the chitin of the ventral wall becomes much thicker, whilst that of the dorsal wall becomes very thin. We have already commented upon this in the case of the air-tree organs in *P. scaber*, and the reason here is the same as there; the strong curved ventral cuticle, together with the very thin dorsal cuticle, enables the creature to bring pressure to bear on these air-holding appendages by flexing the body, and the appendages regain their normal shape when the pressure is relieved.

The special breathing organ will require rather more attention, for it presents some striking differences from those already described under *P. scaber*, and I do not agree with Stoller when he says that the air-tree organs are similar in the two genera. As one looks at the exopodite as a flat object from the ventral side (Fig. 43), the air-tree appears to be composed of several distinct parts, spreading out towards the middle region of the exopodite. Each of these is

CYLISTICUS CONVEXUS



PORCELLIONIDES PRUINOSUS. ♀



*Cylisticus convexus* ♀.

*Porcellionides pruinosa* ♀.



more like a large air cavity ending in smaller branches or tubes than like a tree or bush of many fine inter-locking branches as in *Porcellio*. Fig. 43 represents this organ as seen in transmitted light, the air-holding parts appearing blackish. Towards the outer border four or five dark processes can be seen. They appear white by reflected light. The significance of these will be seen when the dorsal surface is examined. Fig. 44 shows the dorsal surface of this part of the exopodite seen also as a transparent object. It is clear that the main entrances to the breathing trees are situated in a distinct groove, a little distance from the outer border. Into this groove, which runs antero-posteriorly, open the five or six large air trunks or cavities which have already been referred to. Then the four or five dark bands, extending towards the outer border, are seen to be grooved openings leading down into small air-tubes in the more ventral part of the appendage. These small radial grooves have a very characteristic appearance, which I have attempted to draw in Fig. 47, as it is seen under the high power. It is impossible to indicate clearly the differences in levels, as the groove deepens and widens.

I tested all these apertures with warm alcohol, and also by gentle pressure, and saw air bubbles passing out both from the larger cavities which open into the large groove, and from the small special grooves. Further information was obtained from sections. In Fig. 45 one of the large air-cavities is represented extending a considerable way into the exopodite. In Fig. 46 one of the small apertures is figured as it appears in transverse sections. It leads into smaller branched air-tubes in the ventral part of the exopodite.

The surface of the chitinous cuticle is sculptured in the region of these apertures, but the sculpturing is not nearly so prominent a feature as in *Porcellio*. The whole cuticle of these exopodites, indeed of the whole body, is sculptured to a certain extent, but it is in the region of the entrances to the air-tree organs that it becomes sufficiently prominent to hold air. It is clear that this arrangement will prevent water from easily wetting the surface, and so prevent the minute apertures of the air-tree organs from becoming clogged with water. When an exopodite, removed from a living animal, is mounted in water and examined by transmitted light, the air is seen clinging in these small grooves, and when alcohol is substituted for the water, one can watch the air being dislodged.



I mention these details again here because in Leydig's account to be referred to below, he has misinterpreted the function of these minute sculpturings.

The internal chitinous lining of the air cavities and tubes is raised into ridges, forming a maze-like pattern on the wall (Fig. 48). The use of this is the same as the similar pattern on the air-tube walls in *Porcellio* already described. I was able to see the air-cavities spring open again when external pressure was removed, and confirm the observations and conclusions reached in connection with the exchange of air in the air-trees of *P. scaber*. The question of the bringing external pressure to bear upon these air-holding bodies, is taken a stage further in this woodlouse. We have seen that *Cylisticus* can flex the body to such an extent as to bring the ventral surfaces of the head and abdomen together. This power of folding up will be valuable for many purposes, but one of these will be the pressure brought to bear upon the abdominal exopodites and the consequent exchange of air in the air-trees. There is the same prominent ridge of thick chitin situated immediately anterior to the exopodites of the first abdominal appendages, which will press against these exopodites. Of course, I do not mean to imply that it is necessary for the body to be completely flexed to bring pressure to bear on the abdominal exopodites; naturally when this is done the greatest pressure will be exerted, but any slight bending of the abdomen will have its effect upon these very spongy bodies, and a species with considerable power of flexion will more easily exert the necessary pressure. The entrance to the air-holding region is, as we have seen, quite distinct from the entrances to the damp cavities in which the endopodites are found. There is the same lowering and raising of the exopodites, which we have noticed in the other genera to allow air to gain access to the endopodites. The dorsal surface of the exopodites, indeed the whole of the ventral surface of the abdomen and the appendages, are readily wettable, with the exception of the special part at the entrances to the air-tree organs; and a distinct film of water could be seen underneath the exopodites when a living specimen was examined under the microscope. This woodlouse seemed much damper than *P. scaber*.

The exopodite of the 5th abdominal appendage has the same arrangement of long hairs on the dorsal surface as we have noticed in the case of *O. asellus* and *P. scaber*. The ridge with its rows of long seta-like hairs arranged in fan-

like groups is very distinct, and it was in this woodlouse that I first of all became aware of this special "frise" of hairs.

*The Endopodite:* The endopodite is very similar in structure to that of *O. asellus*. It is larger in proportion to the size of the exopodite than in that form. The same parts are found here, and need not be repeated.

The exopodites of the 1st and 2nd abdominal appendages need not be described in detail, for the structure of the air-tree organ has been given in connection with the 3rd abdominal appendage. In all essentials the air-tree organs of the whole five pairs of exopodites are identical.

Stoller in his account of the respiratory organs of this species says:—

"I have carefully examined, both as seen from without and in section, the outer gills (i.e., exopodites) of the 1st and 2nd pairs, and I find that in all essential respects they are identical in structure with the same parts in *Porcellio scaber*. The only differences are such as relate merely to comparative form and size. The descriptions and figures already given for *Porcellio scaber* are applicable to this species, as respects all essential features of structure."

I have already shown that there are substantial differences. He continues:—

"Inasmuch as I have found the structure and relations of the air-holding parts of the gills to be essentially different from what Leydig describes, it may be suitable to quote those passages of his work in which he sets forth the results of his investigations in regard to the main points."

Then follow some thirty lines taken from Leydig's paper. I have read Leydig's paper and studied his figures, and although I agree with Stoller that Leydig is incorrect in his descriptions, I do not feel that Stoller has shown that he quite realises Leydig's mistake. Leydig describes in some detail the antennæ, the eyes, the surface of the body including the peculiar hairs on the legs, of a number of woodlice, before describing the exopodites and endopodites of *Cylisticus convexus*.

Beginning with the endopodite, his first sentence: "Es ist dasselbe nach aussen umgrenzt von einer zarten, doch von Porenkanälen durchsetzten daher senkrecht streifigen Cuticula, oben und unten,"

causes a doubt to arise as to the correctness of his observations, and I agree with Stoller that there are no pores

penetrating the cuticle, although the epithelial layer is certainly striated. The mistake has probably arisen by Leydig misinterpreting surface markings. He remarks that in a previous research he had found something similar in the gill plates of *Asellus aquaticus*. I have examined *Asellus* again, but cannot find what he describes, and Kimus in his valuable researches upon the branchiæ of aquatic isopods shows how incorrect Leydig's observations are. Quoting a description of the branchiæ of *Asellus* by Leydig, Kimus remarks—

"Nous reviendrons plus tard sur celle description et nous verrons qu'elle est bien loin de nous donner une idée nette de la structure des lames branchiales.

"L'auteur reconnaît qu'il n'est pas parvenu à interpréter les apparences qu'il a eues sous les yeux."

Leydig then turns his attention to the exopodite (decklamelle), and we find a similar error here, but one which is more serious because he professes to upset the observations, crude and incomplete as they are, of Lereboullet, Siebold, and Wagner, who described the "corpora alba" as branching sacs with blind closed ends. Leydig says:—

"In Wirklichkeit bestehen solche blindsackige enden nicht."

The earlier investigators did not examine these organs closely, and do not describe histological details, consequently many of their conclusions are incorrect, but Leydig, who makes a closer examination of these exopodites and the air-tree organs, seems to me still further from the real morphological and physiological explanation of these interesting organs. In describing the surface of the cuticle he says:—

"Zerstreut über die ganze Fläche weg vertheilen sich noch kleine pneumatische Räume der Cuticularschicht."

The next extract from Leydig is a part of his paper quoted by Stoller. This, with one or two other extracts from other parts of Leydig's communication, will serve to explain his ideas concerning the air-holding structures.

"Dieselben Zellen scheiden an ihrer freien Fläche, insofern sie die Bluträume begrenzen, eine zarte, die Blutgänge Auskleidende Cuticula ab und diese letztere ist es, welche pneumatisch wird. Die Luft ist in kleinen Höhlen der Cuticula enthalten, daher die 'feine Zertheilung' . . . da ja die Luft in der cuticularen Wand der Bluträume liegt."

In the course of this description Leydig refers to a figure showing a transverse section through the air-holding part of the exopodite. From this figure and his description (a part of which is quoted above) it is clear that he has mistaken air cavities for blood cavities. The air-tubes with the chitinous wall raised into ridges which we have seen as a characteristic feature of these special organs are marked as blood vessels, and are described as such, and the chitinous pattern on the wall is looked upon as an elaborate arrangement of pneumatic pores and canals.

Near the end of the account, he again refers to this character of the chitin, and it seems likely that the property of retaining air in the fine grooves on the chitinous cuticle (to which I have referred at some length) has deceived Leydig into thinking that the cuticle is full of pneumatic spaces. He says—

“dass auch in der allgemeinen Cuticula der Decklamelle  
“ebensolche lufthaltige Höhlen, wenn auch nur in  
“Zerstreuter massiger Menge Zugegen sind.”

He thus misinterprets not only the structure and function of the chitinous sculpturing both on the surface and on the walls of the air-cavities and branches of the air-trees; but also the circulation of the appendages. The blood flows in wide spaces bounded by the epithelium, and is not confined in definite tubes lined by chitin.

Stoller gives no indication of this serious error in Leydig's account and, as far as I can see, has not fully grasped the details of Leydig's description of the air-holding cuticle, for after quoting from his paper he adds:—“It is true that “the air-canals have walls of chitine secreted by the hypoderm, but these canals do not open outwards in pores, but “join one another inwards to form a tree-like cavity which “communicates with the outside of the gill through a single “opening.” This points to the difference being merely one of the kind of exit from air-tubes, whereas Leydig denies the existence of these air-tubes altogether.

When discussing the physiological functions of the air-holding cuticle, Leydig is obviously in great difficulties, for he can see no method of getting any exchange of air in the pneumatic cuticle. One would have thought that this difficulty might have led him to experiment and in time revise his account of the organs. Instead, he doubts whether they have any respiratory function at all—

"Und sonach darf es wieder fraglich erscheinen ob die Luft an dieser Stelle etwas mit der Athmund zu schaffen hat."

I have dwelt at some length upon Leydig's work and Stoller's incomplete description of it, for it is very instructive to realise that both Leydig and Stoller have misinterpreted the function of the surface sculpturings. We have discussed this question in the account upon *Porcellio*. Again, Leydig, although figuring the ridges on the surface of the air tubes in the exopodite misinterprets their significance. Stoller denies their existence or at least dismisses them as wrinkles caused by collapse of the wall. In face of such serious mistakes, there is need for the whole question to be re-stated as plainly as possible, and this I have endeavoured to do.

7. *Porcellionides pruinosus* (Br.).

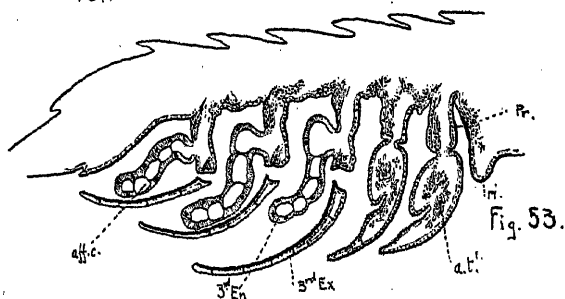
Pl. XIV. and XV., figs. 49-53.

Like *Porcellio scaber* this species has air-tree organs in the 1st and 2nd pairs of exopodites of the abdominal appendages, and in many ways is similar to *P. scaber*, but the abdomen is narrow, and it is much more delicate in build. It bears the same relationship to *P. scaber* as *Ph. muscorum* does to *O. asellus*.

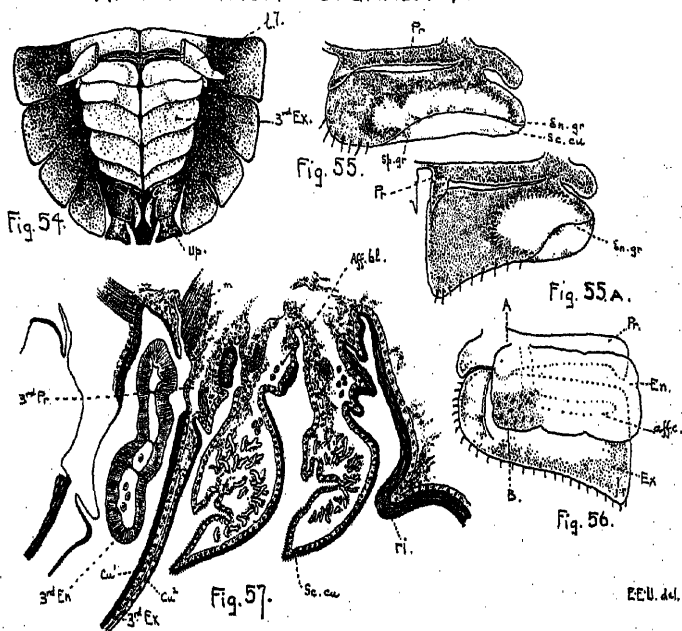
Fig. 49 gives a ventral view of the abdomen of the female, the general arrangement of the appendages is normal. The exopodites are more curved in these narrow-abdomen forms. This may make up, in some way, for the lack of width in the abdomen. The mass of appendages together form a distinct rounded lump, instead of lying flat as they usually do.

*The 3rd Abdominal Appendage:* In Fig. 52 the left appendage is drawn seen from the ventral aspect. The parts are fairly typical. Protopodite, exopodite, and endopodite are all indicated. The protopodite stands well out from the ventral surface, this is shown in Fig. 53, which represents a longitudinal section through the abdomen and appendages. The exopodite fulfils the requirements of an operculum, fitting over the endopodite, and having a distinct ridge on the inner or dorsal surface, acting as a boundary to the endopodite cavity on the outer side. This ridge, which runs posteriorly from the place of articulation, can be seen through the exopodite in Fig. 52.

•PORCELLIONIDES PRUINOSUS. ♀.



ARMADILLIDIUM VULGARE. ♀.



E.E.U. del.

*Porcellionides pruinosus* ♀.

*Armadillidium vulgare* O.



*The Exopodite:* The structure of this exopodite seen as a flat object, and in transverse section, indicates a better blood supply than the corresponding exopodite of *P. scaber*. This is confirmed by observations upon the living creature; but the blood supply is not very good, not nearly so abundant or so vigorous as in the corresponding exopodite of *O. asellus*. The internal structure seen in section shows a wider blood cavity and better developed pillars than in *P. scaber*. The chitinous cuticle of the dorsal or inner wall is much thicker than that of the ventral or outer wall. The outer and posterior margin carries a row of short, stiff, spinous hairs, the inner margin, in its distal region, is covered with fine hairs.

*The Endopodite:* This is in every way similar to the endopodites of *P. scaber*. It has a similar afferent canal, similar epithelial layer with large nuclei and well-developed pillars. (Fig. 53.)

*The Exopodites of the 1st and 2nd Abdominal Appendages:* These exopodites carry the "corpora alba"—the air-tree organs, the shape of the joint and the organs is shown in Figs. 50 and 51.

When the living specimen was under observation it was very evident that a much greater blood supply went to these exopodites than to the remaining normal exopodites.

The air-tree organs are of the same kind as in *P. scaber*. We notice a similar entrance groove, with the surface of the cuticle in that region sculptured; the internal structure of the tree and of the fine branches is the same; the blood supply is essentially the same also. So that all that has been written and figured for *P. scaber* will apply here.

This woodlouse has the same habit of flexing the abdomen, and of holding itself rigid in a flexed condition in very much the same way as *P. scaber*, when danger threatens. There is a very prominent ridge in front of the exopodites of the 1st abdominal appendage, and the methods in use for changing the air in these air-tree organs is exactly the same as described in *P. scaber* or *C. convexus*.

#### 8. *Armadillidium vulgare* (Latr.).

Pl. XV., figs. 54-57.

The number and arrangement of the abdominal appendages in this species is the same as in the other woodlice, their arrangement, seen from the ventral aspect, is shown in



Fig. 54. This figure shows the shallow cavity, semi-circular in outline, which is formed by the flattening and bending down of the lateral plates of the abdominal segments and the blunt uropods. We saw something of this in *C. convexus*, but it is carried much further here.

There are large air-tree organs in the exopodites of the 1st two pairs of abdominal appendages. This species is stoutly built, the cuticle is thick and the chitin is impregnated with lime to a greater extent than in the other genera. The muscular system of the body is well developed.

*The 3rd Abdominal Appendage:* There are no unusual features about this appendage; it is very similar to the corresponding appendage in *P. scaber*. Fig. 56 gives a dorsal view of this appendage removed from the body, seen as a transparent object.

*The Exopodite:* The exopodite of this appendage and also of the 4th and 5th abdominal appendages, is little more than an operculum. In this it also resembles the exopodite of the corresponding appendage of *P. scaber*, but little blood can be seen traversing the blood cavities in the exopodite; and although the ventral or outer wall is much thinner than the dorsal or inner wall, and the exopodite more or less adapted for respiration, yet the same thing, already described in *P. scaber*, has taken place here, and, except at the period of manufacturing a new cuticle, the blood supply is much reduced. This will allow more blood to become available for the more important exopodites of the first and second abdominal appendages which contain the special breathing organs.

Sections through these appendages confirm this observation. The blood cavity in the exopodite of the 3rd abdominal appendage is seen to be much reduced, and a quantity of intermediary tissue—the tissue of the body cavity—is continued into the proximal region of the exopodite, not as a blood directing tissue, but as an obstructing tissue. In Fig. 57, which represents a longitudinal section through the first three abdominal appendages, the 3rd appendage is seen in section taken along a line represented by AB in Fig. 56. The whole length of the exopodite is not shown, but sufficient to show the details of the dorsal and ventral lamellæ with the thick cuticle on the dorsal side and thin on the ventral. The epithelial layers, the intermediary tissue and the reduced blood cavity, are also indicated. The section passes through the protopodite, and the elevator muscle is

seen, which moves the appendage for the breathing action. There is a thick ridge of chitin on the anterior surface of this protopodite; a similar ridge, but broader, is found in the corresponding position on the next protopodite, the 4th abdominal. These thick bands of chitin may have some function in connection with the power of rolling and unrolling.

*The Endopodite:* The endopodite is in every way similar in structure to that described under *P. scaber*. It lies in a cavity bounded by the exopodites, protopodites, and ventral body-wall. It is a cavity but little bigger than the endopodite under normal conditions. In this cavity the endopodite remains in a moist condition covered by a film of water. The boundary walls, viz., the surface of exopodites and ventral body wall, are also damp. If a living specimen is kept under observation under conditions already described on p. 15, the air is seen gradually to work its way under the exopodites as the moisture evaporates in the heat of the table lamp.

The details of structure need only to be enumerated, for they are very similar in essentials to those described in connection with the endopodite of *P. scaber*. The thin cuticle, the spongy epithelial layers, the pillars, the blood cavity, and the special afferent blood channel are all similar. The only difference is in the size of the nuclei of the epithelial layers. They are much smaller in this species than in *P. scaber* or *O. asellus*. Some of these details can be seen in the longitudinal section, but the line of the section AB does not pass through the afferent canal. (Fig. 57.)

The protection of the endopodite by the closely fitting exopodites which reaches an extreme development in this species is related to its power of living in a very dry environment.

*The Exopodites of the 1st and 2nd Abdominal Appendages:* These exopodites carry air-tree organs, and there is no need to describe them in detail. Figs. 55, 55a show the appendages, as they appear from the dorsal aspect as opaque objects. The air-trees are well developed, and there is the sculptured chitin in the region of the apertures of the air-trees as we have described and figured in *P. scaber*. The air-tree of the 1st abdominal segment is well developed, occupying quite three-quarters of the available space, and it seems composed of several trees with several openings in the main transverse entrance groove. The character of the tree resembles those of *Porcellio* and not those of *Cylindricus*, that is to say, the tree is composed of a large number of

branched and interlocking tubes leading off from a main stem. The air-tree nearest the inner border has a special grooved opening which runs in the sculptured face of the dorsal wall opening in a pore not far from the dorso-posterior margin. (Fig. 55.) This groove is similar, in every respect, to the grooves described and figured in the account of *Cylisticus*. There will be no need to repeat here what has already been written as to the structure of the air-tubes, the sculptured wall, the blood supply, and other details of these organs. I have examined and experimented with these air-tree organs in the same way as with those of *P. scaber*, and there are no important differences, apart from the size, the presence of more air-tree organs in one exopodite and the larger entrance groove with several separate passages into the organs.

I have also considered again the question of the changing of the air in these air-tree organs, and the conclusions come to in connection with *Porcellio* and *Cylisticus* are confirmed here. The method of bringing pressure to bear upon these swollen exopodites by flexing the body is very obvious here. In Fig. 57, which represents a longitudinal section through these exopodites, the curious ridge or process can be seen almost touching the outer or ventral surface of the exopodite of the first abdominal appendage. This specimen is only slightly flexed, and it is clear that if the abdomen is still further flexed, pressure will be exerted upon the air-tree holding exopodites. This pressure will drive the air out of the air-tubes, and when the pressure is relaxed by the straightening of the abdomen fresh air will rush into the open air-tubes. The ridges on the air-tube walls cause them to spring open and suck in the air.

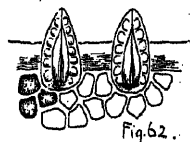
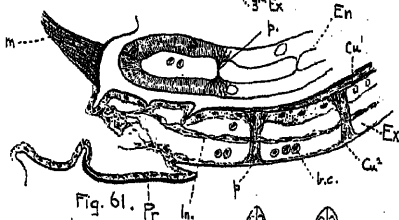
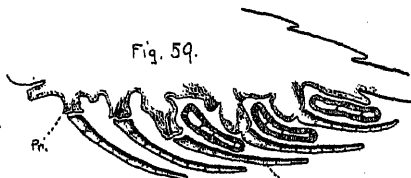
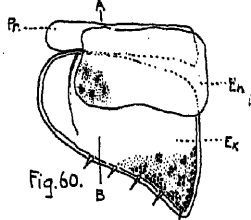
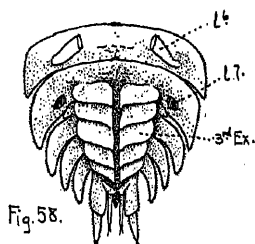
The exopodites of the 5th abdominal appendage show on the dorsal surface the transverse ridge of hairs. This ridge is on the surface just behind the limits of the endopodite, and seems connected with the protection of the endopodite. All the exopodites are more hairy than in the other genera. Those of the 3rd, 4th, and 5th appendages have a row of stiff setae extending along the outer and posterior borders.

9. *Platyarthrus hoffmannseggii* (Br.).

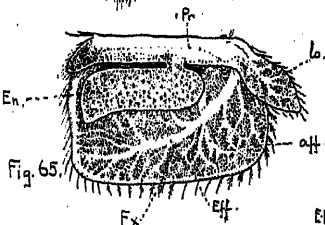
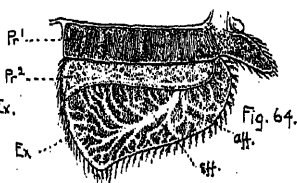
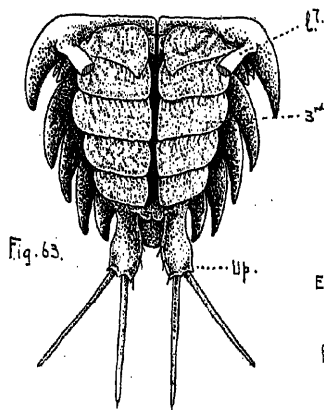
Pl. XVI., figs. 58-62.

If the living creature is examined it is seen that this species resembles *Trichoniscus pusillus* in the structure and function of the respiratory organs. Blood corpuscles can be

PLATYARTHURUS HOFFMANNSEGGII. ♀.



LIGIA OCEANICA ♀



*Platyarthrus hoffmannseggii* ♀.

*Ligia oceanica* ♀.

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seen traversing the blood spaces in the exopodites of all five pairs of abdominal appendages.

There is the same respiratory movement of the exopodites and alternate separation and closing of these plates to allow air to have access to the underlying endopodites. As in the other woodlice the endopodites and all the undersurfaces of the exopodites are damp with a covering film of water. This film of water is seen retreating and advancing when the respiratory movements are watched in an inverted specimen. There are no additional respiratory organs in this form; nothing in the nature of air-trees or the special organs found in *O. asellus* and *P. muscorum*.

*The 3rd Abdominal Appendage:* This is typical with protopodite, exopodite, and endopodite all of usual form. Fig. 60 represents one of these appendages seen from the dorsal aspect. The same appendage is seen in part as it appears in longitudinal section. (Fig. 61). The detailed description follows below.

*The Exopodite:* This is of the usual form. It is devoid of the curious tubercles, which are scattered more or less thickly over the surface of the cuticle in other parts of the body, and which are such a characteristic feature of this woodlouse. The posterior border carries five or six large, pointed bristles.

Examined as a transparent object after treatment with methylene blue one can see that there are wide blood spaces in which blood corpuscles are found. These blood spaces run between the pillars, which are well formed and abundant. The nuclei of the epithelial layer are also prominent. The circulation as seen in the living specimen is much the same as in *Trichoniscus*. The blood enters the exopodite at the point of articulation with the protopodite, and travels towards the inner border. From here it passes down and across the exopodite to find its way out through the efferent canal which runs along the outer border.

The transverse and longitudinal sections confirm these observations, and supply further details. From dorsal to ventral one finds a thick cuticle, a thick layer of cuticular epithelium, a wide blood cavity, a very thin layer of epithelium, almost nothing in places, and a very thin cuticle. Joining the cuticles together are the pillars, and if the section passes through the proximal part of the exopodite, near to the articulation, some intermediary tissue will be

found. These points are all shown in Fig. 61. All these details help to make the resemblance to *T. pusillus* still more marked.

*The Endopodite:* This also is very similar to the endopodites of *Trichoniscus* and *Oniscus*. It is a flat, thick walled sac. The wall is composed of a thick, epithelial layer, with large nuclei, carrying a very thin chitinous cuticle on the surface. A few pillars of the normal type join the epithelium of one side to that of the other. These pillars are very similar to those in the endopodites of *Asellus aquaticus*, which are described in great detail by Kimus in the memoir already mentioned. The pillar really consists of a number of long threads which run from cuticle to cuticle. The narrow part between the two lamellæ consists of the bundle of threads which separate fanwise in each epithelium. The threads mark out a pattern rather like an hour glass in shape or like two cones applied apex to apex.

There is no need to refer to the 1st and 2nd abdominal appendages, for the exopodites of these appendages are similar in every particular to those of the 3rd appendage, which has been described.

I have referred already to the curious tubercles that are present on the surface of the cuticle of the body and limbs. These tubercles are scattered over the dorsal surface in fair profusion and less thickly on the ventral surface. They are especially evident on the edges of the lateral plates and on the dorsal posterior edges of the thoracic and abdominal segments. They give a toothed appearance to these edges. Each tubercle is a flattened scale-like body, not standing out at right angles to the surface of the cuticle, but bent posteriorly at a small angle, so that when the carapace is examined under the microscope, one sees the tubercle almost as a flat object. Its appearance in this position is shown in Fig. 62. There appears to be a central part in the shape of a cone drawn out to a fine point with a surrounding border consisting of an expanded vacuolated wall. There seems to be a canal down the middle of the tubercle or at least some connection with the threadlike extension of the cone. The surface of the cuticle has a characteristic marking, being covered by a pattern of hollows sculptured out of the thickness of the chitin. The absence of pigment and the presence of these tubercles and the sculptured cuticle are responsible for the characteristic white colour of this woodlouse, which is blind and lives as a "pet" in ants' nests.

10. *Ligia oceanica* (Linn.)

Pl. XVI., Figs. 63-65.

Pl. XVII., Figs. 66-71.

*The Abdominal Appendages:* At first sight it seems that the number and arrangement of the abdominal appendages are the same as in the other woodlice. Fig. 63 shows the five pairs of plate-like exopodites overlapping in the usual manner; but upon examination it is found that the 1st and 2nd appendages still retain some traces of endopodites or at least of inner plates in a similar place to the endopodites.

Hewitt says:—"There are five pairs of abdominal appendages or pleopoda and a terminal pair of uropoda. Each pleopod consists of a pear-shaped superior lobe covering a small inferior lamella."

I agree insofar as the 3rd, 4th, and 5th appendages are concerned. The 2nd appendage carries a very small endopodite, but I can find no trace of an endopodite in the 1st abdominal appendage, although the basal part of the appendage, the protopodite to which the exopodite is attached, is large and is divided into two well-defined parts. A full description of these appendages will be given later, after the more normal appendage has been considered.

Observations upon the living creatures confirm Hewitt's short account of the course of the circulation in the exopodites, but his description is too general to be of any value. I, therefore, add a description as seen when the living *Ligia* is observed with the abdominal plates in view.

The blood enters the exopodite at the place of articulation with the protopodite and travels in a wide vessel along the anterior and inner borders.

Branches are given off from this afferent branchial vessel as it passes along the anterior border and down the inner border. These branches subdivide and disappear in the maze of interlocking vessels. There are two other main afferent vessels, distributing blood to the ventral surface: the one, arising from the principal afferent vessel near its proximal end at the place of articulation, passes backward

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I am retaining the terms used throughout, namely, ventral or outer for the surface, which is obviously ventral, as the plates are found, and as they are shown in Fig. 63. Hewitt uses the term "anterior" for this face; strictly speaking it may be anterior, but with the plates lying almost horizontal, the terms ventral and dorsal seem more suitable here, and I have also used anterior, posterior, inner and outer borders to denote the boundaries of the plates regarding them as they appear *in situ*.



across the middle of the exopodite, giving off branches which subdivide still further as they approach the posterior border; the other, a smaller vessel, has a similar course nearer to the outer border. These afferent vessels are plainly nearer to the ventral surface than the other vessels which cross under them. The blood is returned from the exopodite in a system of efferent vessels which, as we have noted, are more dorsal in position, and they open into a large, very prominent efferent vessel, which runs diagonally across the exopodite from the inner posterior corner to the place of articulation. This course of the circulation is substantially the same in all the five pairs of exopodites, Figs. 64, 65, and 66. This feature of the exopodites, the presence of distinct vessels which are plainly visible to the naked eye, is unique among the woodlice.

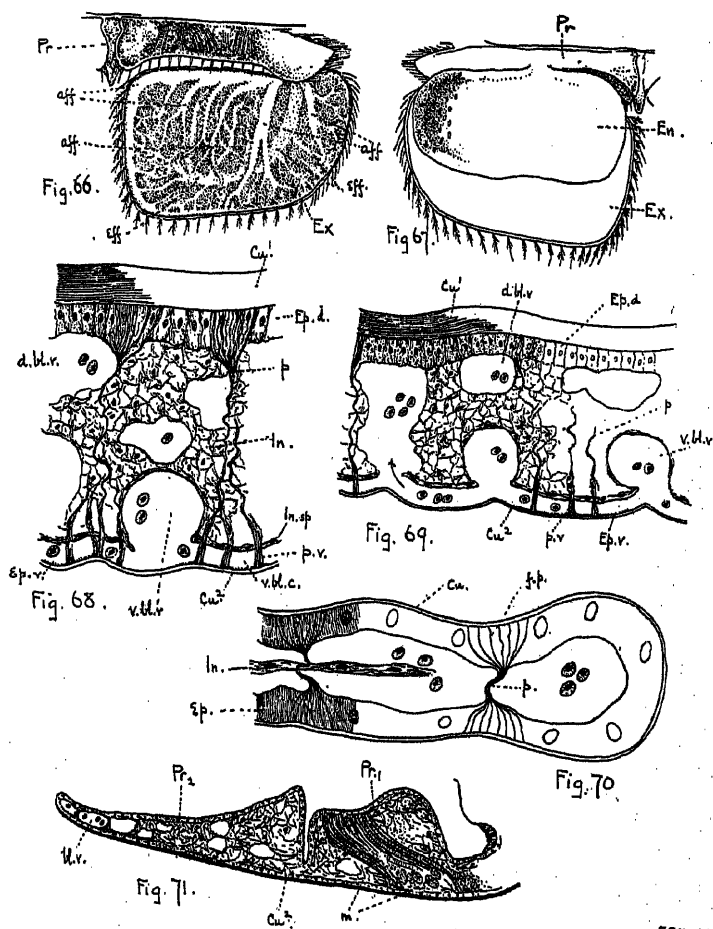
The same respiratory movements of the appendages are seen here as in the other genera described. Also the endopodites and the exopodites are damp, indeed this form gives me the impression of being able to retain a great deal of moisture under the exopodites. No doubt the presence of salt may help in this. The exopodites, besides being intersected by blood vessels and, as we shall see, respiratory in function, act as opercula to the more delicate endopodites, and the dorsal surface is curved in such a way as to enable the exopodite to fit down over the endopodite, and a transverse ridge on the dorsal surface will help to close the cavity in which the endopodite is enclosed.

It will be best to follow the plan which has been adopted in the other species and describe in detail the third abdominal appendage, and then deal with the differences found in other abdominal appendages.

*The 3rd Abdominal Appendage:* This is the largest of all the abdominal appendages. It consists of the three parts: a small horizontal basal part, the protopodite; an outer plate, the exopodite; and an inner plate of smaller size, the endopodite. The shape and general structure will be seen best by examining Figs. 66 and 67, which represent the left appendage seen from both ventral and dorsal aspects. The protopodite is not very different from the protopodite of many of the woodlice (see various figures). The posterior border is fringed with long, spinose bristles and the lateral extension which is somewhat leaflike in outline is fringed with fine hairs.

*The Exopodite:* The shape and the fringe of feathered bristles are seen in Fig. 66 in which an attempt has been

LIGIA OCEANICA. ♀.



*Ligia oceanica* ♀.

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made to show the characteristic appearance of the exopodite when seen either by transmitted or reflected light. The surface is covered by large and small blood vessels, which interdigitate all over the surface, and if the exopodite is treated with methylene blue it is possible to trace with considerable accuracy the afferent and the efferent vessels. There is no need to repeat here what has already been written about the circulation, but in such a preparation of the exopodite one can see plainly the more ventral position of the afferent vessels. One can see them pass on the ventral side of the efferent vessels. By careful focusing one can pass from one wall to the other inspecting the various tissues which lie between the two cuticles. It is clear that the blood vessels on the ventral or outer surface have a different external wall from the vessels near the dorsal surface. The dorsal blood vessels are examined through a thick cuticle and a very uniform layer of epithelium. One can see the regular pattern formed by the nuclei of this layer; whereas the ventral blood vessels can be seen to have a very thin and clear wall, in most cases merely a thin cuticle, or if any epithelium extremely thin and without nuclei. Blood corpuscles can be seen with great clearness lying in small cavities just under the cuticle. The cavities are marked off by what appear to be the ends of pillars, in which nuclei can be seen. If the middle part of the exopodite is examined, a mass of intermediary tissue can be seen filling the exopodite save for the blood vessels.

The cavity of the exopodite, which, in most of the other genera, is a simple blood cavity between the dorsal and ventral epithelial layers, is here invaded by a large quantity of this tissue—very like the body cavity tissue—which has nothing to do with the cuticular epithelium—and which forms the boundary walls of the numerous blood vessels.

Further information is obtained by examining serial sections through this appendage. It is abundantly evident when we examine a section of the exopodite (Figs. 68 and 69), that the ventral surface is adapted for respiratory purposes, for bringing the blood into such a position that only a very thin wall separates it from the air.

The dorsal wall consists of a thick cuticle and a layer of epithelial cells, which are uniform in size, in appearance something like a shallow palisade tissue. The nuclei of this layer are of a good size, and the whole layer is a well formed tissue.

The ventral wall is very different. There is a very thin cuticle, about one-tenth of the thickness of the dorsal cuticle. The epithelial layer is very poorly developed, indeed it is extremely difficult to make out, except in the neighbourhood of the pillars, the ventral ends of which are attached to the cuticle.

The intermediary tissue is remarkable in its great development here. In the exopodites of the woodlice already examined there is very little intermediary tissue. *Oniscus asellus* is the only one in which much is found; in the majority it is restricted to the proximal region in the part near to the place of articulation. Here, however, the exopodite is packed with the tissue. Most of it is like a ground tissue, loose stringy cells with nuclei scattered about. It is obviously a filling-up tissue, and in this it resembles the tissue found in the body cavity. It forms the boundary walls for the blood vessels, and is of great importance in connection with the circulation. The cells are not full of protoplasm, they do not stain deeply, but are rather vacuolated. The nuclei are rather smaller than the nuclei of the dorsal cuticular epithelium.

The tissue is more compact where it forms the wall of a blood vessel, and there is a distinct layer of more compact cells, forming a well defined and constant layer running parallel to the ventral wall a little distance from it. The cells of this layer are more elongated, and the nuclei seem longer also. The effect of this layer is to form a narrow blood cavity all over the ventral surface, just within the very thin cuticle. This cavity is interrupted by the ventral ends of the pillars, so that in the transverse sections the appearance is of a number of cavities side by side. (Figs. 68 and 69.)

The importance of this arrangement of the tissue is obvious, when the respiratory function of the exopodites is remembered. The ventral surface is the surface in contact with the air, the cuticle is thin, there is little or no epithelium, so that with the blood flowing in these cavities the conditions for effective respiration are fulfilled. Thus, the whole ventral surface becomes adapted for the interchange of gases between the blood and air. The width of this blood cavity is such that the blood will travel slowly, and so help in the more efficient interchange. These blood cavities, just beneath the thin cuticle traversed by the pillars, remind one of the

arrangement found in the special respiratory organs on the outer border of the exopodites of *O. asellus*.

The study of transverse and longitudinal sections enables one to carry further the description of the circulation in these exopodites. Dorsal blood vessels from their position and arrangement are little more than conducting vessels belonging to the efferent system already outlined. They are bounded by the thick dorsal wall on the one side and the intermediary tissue on the other. The ventral vessels show very clearly the connections between them and the special cavity of the ventral wall, and here and there the sections show the passage from this ventral cavity to the dorsal system of vessels. So that the blood entering the exopodite is distributed by means of the ventral afferent vessels to the special respiratory cavities which lie just within the ventral cuticle, and then travels from these cavities into the dorsal efferent vessels and so out of the exopodite. (Pl. XVII., Figs. 69 and 66.)

The pillars have already been mentioned, but a rather fuller account of them must be given, for they are rather different from the pillars found in the exopodites of the other genera in the *Oniscoidea*.

A casual inspection of a section through the exopodite might miss the pillars, for the presence of so much intermediary tissue makes them less distinct, but inspection of the ventral wall gives the first clue to their presence, and with care they can be traced across the exopodite from cuticle to cuticle.

If we start from the dorsal wall, the pillar fibres arise from 2 or 3 epithelial cells, to judge by the nuclei, and the fibres which are widely separated to start with run together into narrow bundle. The dorsal part of the pillar has, therefore, a fanlike arrangement of the fibres. The central part of the pillar is in the form of this twisted rope or bundle of fibres which threads its way through the mass of intermediary tissue, to again spread out as the ventral surface is approached. The ventral part of the pillar is, however, very different from the dorsal, the individual fibres do not separate into a fan, but into three or four groups of fibres which, pushing through the special layer of the intermediary tissue, cross the special blood cavity and fasten on to the ventral cuticle. These smaller bundles possibly represent the remains of the ventral cuticular epithelium, for nuclei can be seen in them, and it is what one would expect considering

the formation of the pillars as worked out by Kimus in the aquatic isopods. Although I have given a description passing from one side to the other, the pillar is really formed of cells from each wall, which meet and fuse in the middle.

I have attempted to draw two of these pillars as they appear in a section through the appendage (Pl. XVII., Fig. 68).

*The Endopodite:* The endopodite need not detain us long, for it is very similar to the endopodites of *Trichoniscus* and *Oniscus*. The general form and size as compared with the exopodite can be seen in Fig. 67. Fig. 70 shows the endopodite in transverse section. The thin cuticle, the thick epithelium, the pillars arising from the conical lumps, with their fibres spreading fanwise before becoming attached to the cuticle on either side, are all typical. If the section passes through the proximal region of the endopodite, especially near the place of articulation with the protopodite, a thin layer of intermediary tissue will be found, acting as a tissue directing the flow of blood into or out of the endopodite.

*The 1st and 2nd Abdominal Appendages:* These appendages need some further description, for not only do they differ from Hewitt's description, but they also differ from the general plan found in the other members of this sub-order *Oniscoidea*. We have seen that the woodlice already described in this investigation have lost the inner segments or endopodites of these first two abdominal appendages. *L. oceanica* still retains traces of these inner segments.

*The 1st Abdominal Segment:* When the abdomen of *Ligia* is examined under the simple microscope and the exopodite of the first appendage is lifted up by a needle, a prominent ridgelike inner segment is seen. By moving the exopodite to and fro, it is clear that the exopodite is articulated with the proximal part of this inner segment near to the outer border.

The inner segment is divided into two distinct parts by a transverse suture. The two parts are about equal in area, but are very different in appearance.

If one of these appendages is removed and examined under the microscope further details can be made out. Fig. 64 represents such an appendage seen from the dorsal side as a transparent object. The proximal part of this inner segment to which the exopodite is attached is obviously the protopodite or a part of the protopodite. The presence of a pointed lobe on the outer border of the protopodite beyond the place of the

exopodite articulation is a usual feature in the woodlice, and a similar structure can be seen in Figs. 22, 23, 51, and 55. This seems to confirm the protopodite character of this proximal part. To this is attached another lobe, which looks like a special extension of the protopodite rather than an endopodite. For one thing it is attached along the whole length of the posterior border, for another it resembles in no way an endopodite, rather it more closely resembles an exopodite, as one sees it as a flat object under the microscope. I have attempted to show the structure of the various parts of this appendage as seen in the flat, and the proximal part of this inner segment is full of muscle. The fibres can be seen through the dorsal wall. In the distal part there are blood vessels ramifying through the interior of the plate, which is packed with intermediary tissue. A fairly thick cuticle and epithelium is found on both surfaces, and the free edges are fringed with feathered bristles. Further details are obtained by taking longitudinal sections through the abdomen, and in Fig. 71 is drawn a longitudinal section through this inner section which is under consideration. The proximal part with its mass of muscle, some fibres running from the dorsal to the ventral wall, others at right angles to the section; the distal part with the blood vessels and intermediary tissue and the epithelial layer showing prominently on both walls. Considering all these points I am inclined to the opinion that this inner segment is a two segmented protopodite, and that there is no real endopodite present.

*The 2nd Abdominal Appendage:* The second appendage is quite different from the first. There is clearly here an endopodite, as well as protopodite and exopodite; all three parts are distinct and well defined and normal in structure. Fig. 65 gives a dorsal view of this appendage. A large exopodite with blood vessels similar to those in the exopodite of the 3rd abdominal appendage, a small endopodite, about one-third of the size that it should be if it were normal, and a protopodite to which these two plates are attached. The lobe of the outer border is here unusually large and leaflike, and has a system of blood vessels very much the same as the exopodite. The small endopodite as seen in transverse section is typical in every way.

It is interesting to find these differences in the first two pairs of abdominal appendages. The woodlice, which are established further inland, have lost the endopodites of these first two appendages. It is clear from their structure and by



comparison with aquatic forms, that the endopodites are respiratory organs for use in water, and that they are useless on land unless they can be kept very damp. The exopodites have, on the other hand, become adapted for air breathing only, and function in a drier state. The first two abdominal appendages are in a favourable position for air breathing, but unfavourable for the endopodite or gill respiration, and this may have caused the loss of these parts in most of the *Oniscoidea*. Whether this is so or not, *L. oceanica* is nearer to the aquatic types than any other member of the *Oniscoidea*, and the fact that there is no endopodite in the 1st and a small one in the 2nd abdominal appendages, helps us to bridge the gulf between marine isopods and the land isopods.

### SUMMARY.

#### GENERAL REMARKS.

It seems best to attempt a brief summary of the main points of interest which have been brought to light in the foregoing investigations, and to give a general account of the respiration of land isopods in light of these researches.

*Abdominal Appendages:* We have seen that the first five pairs of abdominal appendages take some part or other in respiration. A typical appendage consists of a basal part—the protopodite, an outer plate—the exopodite, and an inner plate—the endopodite.

In *Trichoniscus*, *Oniscus*, *Philoscia*, *Porcellio*, *Porcellionides*, *Cylisticus*, *Armadillidium*, and *Platyarthrus*, the 1st and 2nd abdominal appendages have no trace of endopodite. In *Ligia* only the 1st abdominal appendage is without the endopodite, although the protopodite of this appendage is very large and divided into two distinct parts (Fig. 64). The endopodite belonging to the 2nd abdominal appendage is small, about one-third the normal size (Fig. 65).

The arrangement of the abdominal appendages is the same in all the various genera; the exopodites are ventral and external, overlapping from in front backwards and covering the endopodites as opercula. (Figs. 1, 7, 17, 19, 21, 41, etc.) Both exopodites and endopodites are respiratory in function.

*The Exopodite:* Normally an operculum, it has become adapted for respiration by having the ventral or outer wall extremely thin, so that the blood within the exopodite is only

separated by a very thin membrane from the air outside. In the aquatic genera if there is any difference in the walls, the ventral wall is the thicker. This is seen in the exopodites of the 3rd abdominal appendage of *Asellus*, and in all the exopodites of *Cirolana*.

The simplest form of exopodite is found in *Trichoniscus* and *Platyarthrus*, that is to say, in these genera the exopodite closely resembles the normal type seen in the aquatic isopods, except for the thickness of the ventral wall. The exopodite consists of a flattened sac in which a simple blood cavity is found between the dorsal and ventral walls, which are formed of a cuticular epithelium and a chitinous cuticle. Crossing the cavity are the pillars, epithelial structures joining the wall of one side to the wall of the other. (Figs. 6, 61.) Another tissue is found in the exopodites, although it is much less evident than in the aquatic genera. It will be seen in the protopodite and extending a short way into the exopodite as a blood directing tissue. (Figs. 4 and 61.)

Although this is the normal type of exopodite there are not many genera which retain this simple form; perhaps the nearest being the exopodites of the 3rd, 4th, and 5th abdominal appendages in *Porcellio*, *Porcellionides*, and *Armadillidium*, and the chief part of the same exopodites in *Oniscus* and *Philoscia*. In the case of the former three genera, the blood cavity is much reduced, and there is but little respiration performed by them, the reason for this is the formation of very efficient breathing organs in the exopodites of the first two abdominal appendages. These air-tree organs take over, as it were, the type of respiration performed by the exopodites as a whole, and so, although originally adapted for the purpose, these last three pairs of exopodites lose their respiratory function.

Leaving *L. oceanica* for the moment, there are two quite different ways in which the exopodites of certain genera are modified to make them more efficient respiratory organs. The one kind of special respiratory organ is found in *Oniscus* and *Philoscia*—the other kind in *Porcellio*, *Porcellionides*, *Cylisticus*, and *Armadillidium*.

The first kind is a special thin extension of the outer border of the exopodites, forming small lung chambers; the second kind is an invagination of the outer wall of the exopodite to form a branching tree of air-tubes, which have very thin walls. In the first case, the blood flows through radial passages in the thin walled plate, and the air bathes the sur-

face of the special organ: in the other, the blood within the cavity of the exopodite bathes the surface of the air tubes, which have a large opening on the posterior dorsal surface of the exopodite. In each case air is brought into intimate relation with the blood, so that only a very thin membrane separates the two media.

In *L. oceanica*, however, we meet exopodites of quite a different type. Instead of the cavity of the exopodite being a simple blood cavity crossed by the pillars, and in places divided into two parts by a plate of intermediary tissue, the cavity has been invaded by the intermediary tissue to such an extent as to confine the blood to a definite system of blood vessels, the walls of which are partly formed by the cuticular epithelium and partly by this intermediary tissue—a tissue of mesoblastic origin. There are ventral vessels, the afferent system, leading into a network of narrow cavities which cover the ventral surface and lead into dorsal vessels—the efferent system.

We have here a very different type of exopodite from any of the other members of the *Oniscoidea*, and indeed the amount of intermediary tissue is greater than in any of the aquatic forms described by Kimus. The reason for this difference seems to me to be associated with its large size and the fact of becoming terrestrial. The large exopodites of *Ligia*, especially in comparison with the genera most nearly related, e.g., *Trichoniscus* and *Ligidium*, do require an internal supporting tissue in a way that the exopodites of the others do not. The intermediary tissue is the same kind of tissue which is found performing the same kind of supporting and filling-up functions in other parts of the body. The point to notice here is that the circulation is so arranged that the blood in the exopodite is conducted to the small cavities on the ventral face where there is only a very thin cuticle separating it from the air. In this way the exopodite is adapted for respiration in air.

*The Endopodite:* Unlike the exopodites which exhibit considerable variation, the endopodites are practically identical in structure throughout the sub-order *Oniscoidea*. In every genus examined, the endopodite can be described as a thick walled, flattish sac containing blood. The wall is very constant in composition, being formed of a thick spongy epithelium, the cells of which are not easily distinguished except by the large nuclei. The protoplasm of the cells has much the same character in all the species—a striation

running at right angles to the surface. The epithelial layer carries thin cuticle on its outer surface, and on its inner surface is in the form of conical protuberances which join across the cavity in pairs to form the characteristic pillars. The spreading fibres of the pillars can be traced through the protoplasm to the cuticle to which they appear to adhere. The endopodites of *Asellus* are very similar. Intermediary tissue is found in the protopodite to which the endopodite is attached, and in some genera it extends a little way into the endopodite. In this case its function is similar to that of the intermediary tissue found in the proximal region of the exopodite, namely, the proper directing of the blood entering and leaving the plate.

In three of the genera examined, *Porcellio*, *Porcellionides*, and *Armadillidium*, the arrangement for the blood is rather different. A special afferent canal is formed by an alteration in the thickness of the ventral epithelial wall at one place. Instead of the thick spongy layer, one finds a narrow layer of quite small cells, rather like intermediary tissue cells, forming an arched wall in a narrow band running back from the place of articulation, tracing out, in the larger endopodites, the letter L. The details of this tube are fully described in *P. scaber*. Also see Figs. 31, 32, 53, 56.

I do not propose to discuss here the minute histological details of the various tissues of these respiratory appendages. Kimus, in his account of *Asellus* and other aquatic isopods, to which reference has been made, has described in considerable detail the histological features of tissues which are similar in every way.

I do not feel able, however, to pass over the question of the pillars and the intermediary tissue without some little attention, for some of the chief points of interest in the work of Kimus are centred around the pillars and the intermediary tissue. Taking the pillars first, it will be well to see how they compare with those found in the aquatic genera.

Kimus distinguishes several different kinds of pillars:—

“Certaines cellules épithéliales d’une face s’unissent à  
“des éléments de l’autre face au travers, de la cavité  
“branchiale pour former des piliers multicellulaires.

“Parmi ceux-ci, on en distingue de bicellulaires, formés  
“par l’union d’une seule cellule d’un côté avec une seule  
“cellule de l’autre. Cette disposition s’observa dans les  
“piliers de l’exopodite de la *Cirolana*.

"D'autres sont au contraire formés d'un plus grand nombre d'éléments voisins appartenant à chacune des faces. Ce sont alors des colonnes formées par la juxtaposition de plusieurs piliers bicellulaires. Nous avons signalé cette variété chez l'*Anilocra*, la *Cymothoa*, l'*Idotea*, et dans la zone protectrice d'exopodite de l'*Asellus*. Une cellule épithéliale peut contracter des rapports, non avec une cellule de la lamelle d'en face, mais directement avec la cuticule de cette dernière. Pour cela, elle a dû écarter certaines cellules de la couche cuticulaire, dénuder la cuticule, et s'y fixer par son extrémité. Ces cellules constituent des 'piliers simples' et unicellulaires. Ici se présente aussi le cas où les piliers sont formés par la juxtaposition de plusieurs éléments appartenant à la même face. Ce sont alors des piliers multiples et unicellulaires. Enfin certaines cellules contractent avec une cellule située en face des rapports plus complexes que ceux que nous venons d'indiquer.

"Au lieu de s'abuter par une extrémité simple avec une extrémité semblable de la cellule opposante, elles présentent une série de protubérances qui s'unissent à des productions toutes semblables appartenant à des cellules qui leur font face. Ces diverses protubérances sont bien distinctes, isolées les unes des autres: le sang circule entre elles.

"Chacune de ces cellules contribue donc à former non pas un seul pilier, mais plusieurs. On peut leur donner le nom de cellules multicolonnaires. Ces éléments, extrêmement remarquables, s'observent chez l'*asellus aquaticus*, dans les lames internes (endopodites) et dans la zone branciale des lames externes."

The pillars found in the sub-order *Oniscoidea* are for the most part of the simpler kind. In the exopodites of *O. asellus*, *T. pusillus*, and *Platyarthrus*, "piliers simples" are found and "piliers bicellulaires" also. (Figs. 6, 13, 61.) These are very similar to the pillars figured and described by Kimus in the operculum of *Asellus* and in the exopodites of *Idotea*.

We have seen that in the genera *Porcellio*, *Cylisticus*, *Porcellionides*, and *Armadillidium* pillars are not well developed. In the exopodites which contain the air-tree organs, one or two rather prominent pillars are found joining the dorsal and central walls together around the outskirts of the air-tree organ, where the two faces come into normal relationship to one another. (Fig. 33.) These are of the

bicellular type and "multiple." The endopodites of all the genera have pillars which resemble in every way those figured and described, by Kimus, in the endopodites of *Asellus*. They are not formed of complete cells, but by the fusion of processes from the large epithelial cells—les cellules multicolumnaires. However, in most genera these cells are not so large as those found in *Asellus*, and do not carry so many pillars. (Figs. 5, 15, 16, 32, 61, 70.) The most unusual type of pillars are those found in the exopodites of *L. oceanica*. (Figs. 68, 69.) They resemble in a general way the type found in the endopodites, that is to say, radiating threads or fibres can be traced to each cuticle, but they are fundamentally different from these, for they are multicellular. Several cells on each face give rise to them. A full description has already been given of these pillars in *Ligia*.

*Function of the pillars:—*

1. They will prevent the too wide separation of the dorsal and ventral walls. "De longues colonettes minces comme celles de la lame externe de l'*Asellus* ou des *Cloportes*, ne peuvent évidemment servir qu'à limiter l'écartement des deux lamelles." (Kimus.)

2. The more robust pillars would prevent the flattening of the plates when external pressure is applied. "L'un et l'autre de ces mouvements exagérés doivent être évités pour le fonctionnement régulier de l'organe. En effet, si les deux lamelles pouvaient s'écarter librement, l'organe tendrait à prendre une forme vésiculeuse,—c'est une loi physique,—à la moindre perturbation qui pourrait se produire dans le courant efférent, le canal afférent continuant à déverser le sang dans l'organe. Dès lors, une stagnation plus ou moins accusée du sang respiratoire pourrait se produire. Si au contraire une pression extérieure s'exerçait sur les lamelles, la cavité pourrait se trouver complètement effacée et la circulation branchiale serait arrêtée. Il semble donc certain qu'en toute hypothèse les piliers jouent ce rôle passif." (Kimus.)

3. Contractility: Kimus goes further and described the power of contractility possessed by many of the pillars. Some of the genera studied by him—*Cirolana*, *Anilocra*, and *Cymothoa*, have large and very extraordinary pillars, with a striking resemblance in structure to muscle-fibres.—"L'impression," he says, "qui nous reste de l'étude de tous les piliers que nous avons examinés est que la substance des

"faisceaux délimités présente une structure plus semblable "à la structure musculaire. Qu'aucune autre production "cellulaire dont nous ayons connaissance."

Other facts are brought forward, the innervation of the pillars; direct observation of a fluttering movement in the lining branchiæ of *Asellus*, the different sizes of the internal cavity in the case of the endopodites, when seen in transverse section, and they lead up to the conclusion.—"La structure, les "réactions, l'innervation des piliers et l'observation des "organes vivants ou fixés, concourent à nous démontrer que "ces productions sont données d'une contractilité semblable à "celle des fibres musculaires.

"Il existe donc chez les édriophthalmes des cellules épithélio-musculaire."

In the *Oniscoidea* as a whole the pillars of the exopodites are not particularly well developed. They are mostly of a simple type, and not present in great numbers. Their function here seems of the passive kind preventing the collapse or the too great widening of the internal cavity. Possibly the small size of the exopodites in most genera would account for the lack of the contractile character. In the case of *Ligia oceanica*, it seems feasible that the pillars in the wide exopodites will have a contractile function, for the presence of the intermediary tissue and the consequent formation of blood-vessels will do away with the dangers of collapse and over extension. Yet the pillars are quite distinct, and the fibres united into bundles "faisceaux de fibrilles" run from cuticle to cuticle. Their appearance too favours the contractile nature, and also the advantage, in promoting more efficient circulation in the ventral cavities, of the power of contractility, is obvious. I examined the ventral surface of the exopodites of a living specimen, and there did appear to be some slight movement of the surface, something to which the name "fluttering movement" might be given, but I am in doubt as to the wisdom of counting this observation as evidence, for it is difficult to be quite sure of such movements, and I may have been influenced by Kimus's account. However, I offer the observation for what it is worth. It seemed clear to me at the time.

The pillars in the endopodite certainly appear to be contractile. The chief evidence apart from structure, is the very varied size of the internal cavity, as seen in transverse section.

*The Intermediary Tissue:* Kimus has given this name to the tissue which is found in the cavity between the two epithelial walls of the exopodite and endopodite, and which in the proximal region of either plate is continuous with the same kind of tissue in the protopodite and in the body cavity. Its use is to direct the blood. This function will be seen illustrated in several of the Figs., especially in the exopodites which bear air-tree organs. (Figs. 34, 35, 61.) In *Oniscus* its use is still further extended. As a rule in the exopodites and endopodites its presence is restricted to the part near by the place of articulation, but in *Oniscus* it is found acting as a horizontal partition in the special breathing organs (Figs. 11, 12, 14.) *L. oceanica* is also an exception, and differs from the other *Oniscoidea* in having the exopodites packed full with this tissue. This special case has been already dealt with in the communication on *Ligia*.

Although this tissue is more prevalent in the aquatic isopods than in the terrestrial forms (except *Ligia*) there are no differences in structure to note, and reference should be made to the memoir by Kimus.

*General Remarks upon Respiration:* The whole problem of respiration in the terrestrial isopods is much more complicated than in their aquatic relatives. Organs adapted for absorbing oxygen that is dissolved in water, cannot easily be made to act in the air. It seems to me that the woodlice have two rather distinct methods of respiration, the one method not very different from that of the aquatic forms; the other adapted more for obtaining oxygen from ordinary air.

The obvious respiratory organs for aquatic life seem to be of the "endopodite" type, that is to say, a blood sac with a thick spongy wall composed of an epithelial layer and a thin cuticle. In *Asellus aquaticus* even the exopodites have somewhat this structure, and the same thing is found in *Anilocra* and *Cymothoa*. Kimus devotes some attention to the matter, and concludes that the thick wall of spongy protoplasm is a most efficient wall for the respiratory exchange, and that the living protoplasm plays some important part in obtaining the oxygen. He concludes by saying:—

"Le gaz qui a traversé la cuticule et pénètre dans la masse protoplasmique vivante, dans ce laboratoire de la cellule où se produisent tant de réactions, va-t-il passer en totalité? Ou bien ce protoplasme ne va-t-il pas, au contraire, le retenir, en grande partie et former des corps, oxydés qu'il



"utilisera lui-même ou déversera peut-être dans le sang?" Rien ne prouve que l'épithélium lamellaire laisse passer tout l'oxygène qu'il absorbe. On peut faire la même remarque chez d'autres animaux, les vertébrés par ex. Chez les édirophthalmes, le fait que la couche de protoplasme qui sépare le sang du milieu extérieur est plus puissante dans les positions qui doivent être les plus respiratoire, est une indication sérieuse. Elle paraît montrer que, chez ces animaux au moins, le protoplasme vivant joue un rôle dans l'absorption et l'utilisation de l'oxygène."

Now the endopodites of woodlice are without exception of this same type—having thick spongy walls. One may conclude, therefore, that they are adapted for a similar method of respiration. How is this possible in a terrestrial habitat? We have seen how that the endopodites of all the woodlice have been found to be very damp, to be covered with a distinct film of water, and this, not only in those living in damp situations, but in the "drier" species too. And it seems clear to me that in retaining the "gill-like" character of the endopodites, the woodlice have perforce to retain a film of water around these endopodites to act as the medium for oxygen and carbonic acid gas. The layer of water will have its available oxygen constantly renewed, as the air is drawn beneath the exopodites during the breathing action, and the endopodites are then able in some way to absorb this oxygen through the medium of this film of water. Of course, this is not a very satisfactory method, and there is the great danger of "drying up"—a peril very real to all the woodlice.

The other method of respiration is an attempt to solve the problem by obtaining a very thin membrane between the blood and the air. This extreme thinness of the respiratory membrane is found in the case of the air cells in the lungs of vertebrates, and seems as important for ordinary air breathing as the thick wall was for the aquatic method.

The exopodites are adapted for this purpose. The simplest adaptation is to use the whole ventral surface as a respiratory surface. This is what we find in *Trichoniscus*, *Platyarthrus*, and in a different way in *Ligia*. That this has been, as it were, the first and simplest method is shown by the fact that in all the genera the ventral or outer wall is thinner than the dorsal. The normal arrangement is the direct reverse of this.

In the other genera of *Oniscoidea* methods are found whereby the respiratory surface is obtained in a still thinner

condition. In *Oniscus* and *Philoscia* special thin-walled border organs are found, and in *Porcellio*, *Porcellionides*, *Cylisticus*, and *Armadillidium* a much more satisfactory method has been developed in which there is much less likelihood of the danger of desiccation. This is by the formation of the air-trees, invaginations of the outer wall of the exopodite in the form of branching air-tubes. The term "lung-trees" might be used, for they are restricted in extent, and the blood plays an important part. We have here an independent attempt to solve the problem of aerial respiration in the *Arthropoda*, and in many ways it is comparable to the methods found in the *Insecta* and *Arachnida*. However, the woodlice are severely handicapped in the matter of respiration by the small size of these organs and their inability to do without the endopodites. These facts have caused the range of the woodlice to be rather limited, for they have to seek for places where conditions will be favourable for both methods of breathing.

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## EXPLANATION OF PLATES.

## PLATES X. TO XVII.

Abbreviations used in all figures.

Cu., cuticle.

Cu<sup>1</sup>., cuticle of inner or dorsal wall.\*

Cu<sup>2</sup>., cuticle of outer or ventral wall.\*\*

Ep., epithelium of wall.

In., intermediary tissue.

Pr., protopodite.

Ex., exopodite.

En., endopodite.

1st Ex., 3rd Ex., etc., exopodite of 1st or 3rd abdominal appendages, etc.

p., pillar.

b.c., blood corpuscle.

n., nucleus.

1<sup>6</sup>, 1<sup>7</sup>, 6th of 7th walking legs, in all cases cut short or removed entirely.

up., uropods.

Other references are given under the details of each figure.

\*, \*\*. The terms "dorsal" and "ventral" are used to distinguish the two walls of the exopodite or endopodite.

"Ventral" is the obvious ventral face taking the appendage as being practically horizontal (= inferior, external, anterior).

"Dorsal" is the obvious dorsal face (= superior, internal, posterior).

## PLATE X.

*Trichoniscus pusillus*.

Fig. 1. Ventral view of the abdomen of female. × 15.

Fig. 2. Ventral view of the 3rd abdominal appendage of left side. × 50.

aff., afferent canal running along inner border.

eff., efferent canal running along outer border.

Blood spaces between the groups of dots, which represent pillars.

Fig. 3. Dorsal view of the 3rd abdominal appendage (left). × 50.

En. lo., lobe of the endopodite.

Fig. 4. Longitudinal section through the abdomen. Semi-diagrammatic.  $\times 75$ .

n.c., nerve cord.

4th Endo., endopodite of 4th abd. appendage.

This figure illustrates arrangement of exopodites, endopodites, and protopodites. Note thin *ventral* wall of exopodites.

Fig. 5. Transverse section of Endopodite (a part only shown.)  $\times 350$ .

n., nucleus of the thick epithelium.

p., pillar with radiating fibres attached to the dorsal and ventral cuticle.

b.c., blood corpuscle in the blood cavity.

Fig. 6. Transverse section of Exopodite (a part only shown.)  $\times 350$ .

aff., the afferent blood canal.

Ep., the epithelium of the dorsal or inner wall.

The epithelial layer of ventral wall is very thin as is the ventral cuticle Cu<sup>2</sup>.

## PLATE XI.

### *Oniscus asellus*.

Fig. 7. Ventral view of abdomen of female.  $\times 4$ .

The 3rd appendage of the right side is turned forward to show the protopodite and endopodite. Notice also "special breathing organs" on the outer borders of exopodites.

Fig. 8. Ventral view of 3rd abdominal appendage (endopodite omitted) of the right side.  $\times 15$ .

Methylene blue treatment:

Ex<sup>1</sup>, the ordinary part of exopodite.

Ex<sup>2</sup>, the special respiratory part.

Fig. 9. A small part of Ex<sup>2</sup> of Fig. 8 more highly magnified. Radial blood cavities shown.

Fig. 10. Dorsal view of 5th abdominal appendage.  $\times 15$ .

This shows the special row of hairs "like a cheval-de-frise." Fr.

dr., the dorsal ridge marking the boundary between the two parts of the exopodite.

Figs. 11, 12, 13, 14. Illustrate details of the Exopodite seen in T.S. & L.S.

Fig. 11. The outer part of Exopodite in transverse section.  
× 75.

dr., the dorsal ridge as above.

bl. c., blood cavity.

In., intermediary tissue.

Fig. 12. Portion of "special respiratory organ" of Exopodite in T.S. × 100.

n., nucleus of simple epith. pillar.

In. par., intermediary tissue forming partition.

Fig. 13. The inner part of Exopodite in T.S. × 75.

Fig. 14. Longitudinal section through parts of the 1st two abd. Exopodites. × 75.

Ex<sup>a</sup>, special respiratory part of 1st.

Ex<sup>b</sup>, ordinary part of 2nd.

d. bl. c., dorsal blood canal.

v. bl. c., ventral blood canal.

In. par., partition of intermediary tissue.

A. ch., "air pocket" or "lung cavity." The air retained in this cavity gives the silvery appearance.

Fig. 15. Semi-diagrammatic transv. section of Endopodite.

Fig. 16. Longitudinal section through the 3rd abd. appendage. × 50. The line of section is through the place of articulation of Endopodite with Protopodite.

## PLATE XII.

### *Philoscia muscorum.*

Fig. 17. Ventral view of abdomen of female. × 7.

Fig. 18. Ventral view of 3rd abdominal appendage, right side. × 15.

(Seen as a transparent object.)

Ex<sup>2</sup>, special respiratory part of Exopodite.

En., Endopodite (shaded in to show up).

### *Philoscia couchii.*

Fig. 19. Ventral view of abdomen of female. × 7.

Fig. 20. Ventral view of 3rd abd. appendage of left side. × 15.

Note the small size of the respiratory part.

*Porcellio scaber.*

- Fig. 21. Ventral view of abdomen of female.  $\times 6$ .  
Air-tree organs in Exopodites of appendages 1 and 2.
- Fig. 22. Ventral view of the 1st abdominal appendage of right side.  $\times 18$ .  
(Seen as an opaque object.)  
The letters refer to sections represented later.
- Fig. 23. Dorsal view of the 2nd abdominal appendage of right side.  $\times 18$ .  
(Seen as an opaque object.)  
a.t., air-tree organ.  
gr., the main entrance groove leading to air-tree.  
sc. a., sculptured area of the cuticle.  
AB, line of section Fig. 33.
- Fig. 24. Ventral view of 3rd abdominal appendage of left side.  $\times 18$ .  
(Seen as a transparent object.)  
aff. c., aff. blood canal of Endopodite shown in outline.
- Fig. 25. Longitudinal section through the abdomen.  $\times 25$ .  
ri., transverse ridge, important in connection with exchange of air in air-trees.  
a.t.1, air-tree organ of 1st abd. appendage.  
a.t.2, air-tree organ of 2nd abd. appendage.  
Fr., the "frise" of hairs.

## PLATE XIII.

*Porcellio scaber* (continued).

- Fig. 26. Part of a longitudinal section of 3rd abd. appendage.  $\times 45$ .  
(Endopodite omitted.)
- |   |   |  |
|---|---|--|
| Ep <sup>1</sup> , Epithelium of dorsal wall.<br>Ep <sup>2</sup> , Epithelium of ventral wall. | { | The specimen was one which had just moulted. Epithelium very distinct. |
|---|---|--|
- Fig. 27. Small part of Exopodite in L.S.  $\times 45$  from normal specimen. The epithelium is vacuolate, nuclei prominent; distinct inner boundary wall of tissue—(ch.); very narrow blood cavity.

Fig. 28. Small part of a longitud. section of an exopodite shortly before ecdysis.  $\times 50$ .

Notice the character of cuticular epithelium, and size of blood cavity.

O. Cu<sup>1</sup>, old cuticle of the dorsal wall.

N. Cu<sup>1</sup>, new cuticle of the dorsal wall.

O. Cu<sup>2</sup>, old cuticle of the ventral wall.

N. Cu<sup>2</sup>, new cuticle of the ventral wall.

Fig. 29. Small portion of the Exopodite in the proximal region seen as a transparent object after treatment with methylene blue. The lighter patches represent the blood spaces.

Fig. 30. Dorsal view of the 3rd abdominal appendage of right side.  $\times 18$ .

Methylene blue treatment.

Protopodite and Exopodite shown in outline only.

Fig. 31. Ventral surface of Endopodite (methylene blue).  $\times 18$ .

aff. c., the ventral wall of afferent blood canal.

AB. line of section of Fig. 32.

Fig. 32. Longitudinal section of Endopodite (along AB in Fig. 31).  $\times 100$ .

n., nucleus of epithelium, Ep.

aff. c., afferent blood canal.

v.e. aff. c., ventral wall of same.

Fig. 33. Transverse section of the 2nd abdominal Exopodite.  $\times 35$  (line of section AB in Fig. 23).

En. gr., main entrance groove.

p., pillars in the normal part of Exopodite.

Cu<sup>2</sup>, ventral cuticle, *thick*.

Figs. 34 and 35. Longitudinal sections through the 1st abd. Exopodite taken along lines AB and CD in Fig. 22.  $\times 35$ .

These figures illustrate the blood supply to the air-tree.

aff. c., afferent canal. Eff. c., Efferent canal.

Fig. 36. One of the small branches of the air-tree organ.  $\times 100$ .

Note character of the wall.

Fig. 37. Portion of the outer part of the air-tree organ in L.S.  $\times 150$ .

cu., cuticle of the wall of Exopodite with its epithelium (cu. ep.).

a.t.cu., cuticle of air-tube. Note the ridges on the walls.

a.t. ep., epithelium of the air-tube represented by trace of protoplasm round the nuclei and the persistent chitinous inner boundary of tissue.

bl. c., blood cavity.

Fig. 38. Small portion of the sculptured cuticle from sides of entrance groove (surface view).

Fig. 39. Similar section to that in Fig. 37 taken at a time when the new cuticle is being formed. The epithelium of air-tubes is very distinct at this time. Compare it with the epithelium in Fig. 37.

Fig. 40. Longitudinal section of 1st abdom. Exopodite taken along line EF in Fig. 22.  $\times 75$ .

This shows the general structure of the Exopodite and air-tree organ.

Cu<sup>2</sup>, thick cuticle of ventral wall.

Cu<sup>1</sup>, thin cuticle of dorsal wall.

En. gr., entrance groove to air-tree.

Sc. cu., sculptured cuticle—the limits of this area are shown.

#### PLATE XIV.

##### *Cylisticus convexus.*

Fig. 41. Ventral view of abdomen of female.  $\times 7$ .

Fig. 42. Part of a transverse section through the abdomen in the region of the 3rd abd. appendage.  $\times 20$ .

Ex., Exopodite containing air-tree organ.

En., Endopodite.

l.p., lateral plate of abdomen.

g., alimentary canal.

n.c., nerves from n. cd.

Fig. 43. Ventral view of the 3rd abdominal appendage.  $\times 25$ .

(Seen as a transparent object.)

Fig. 44. Dorsal view of the outer part of Exopodite.  $\times 25$ .

En. gr., main entrance groove to air-tree.

s.g., special entrance groove.

Fig. 45. Transverse section through the Exopodite (along AB in Fig. 44).  $\times 75$ .

En. gr., main entrance groove.



Fig. 46. Transverse section of same passing through a special entrance groove.  $\times 75$ .

[Only a portion of the sections drawn in Figs. 45 and 46.]

Fig. 47. One of the special entrance grooves seen as a transparent object, with the air retained within.  $\times 100$ .

The shallow sculpturing of the surface cuticle is shown.

Fig. 48. Small portion of wall of air-tree organ showing the ridge markings.  $\times 75$ .

*Porcellionides pruinosus.*

Fig. 49. Ventral view of the abdomen of female.  $\times 12$ .

Fig. 50. Dorsal view of the 1st abdominal appendage of left side.  $\times 35$ .

Fig. 51. Dorsal view of the 2nd abdominal appendage of left side.  $\times 35$ .

(Both seen as opaque objects.)

Fig. 52. Ventral view of the 3rd abdominal appendage of left side.  $\times 35$ .

(Seen as a transparent object.)

PLATE XV.

*Porcellionides pruinosus* (continued).

Fig. 53. Longitudinal section through the abdomen.  $\times 35$ .  
a.t.<sup>1</sup>, air-tree organ of 1st abd. appendage.  
aff.c., afferent blood canal of Endopodite.  
ri., ridge for pressure on air-tree for expiration.

*Armadillidium vulgare.*

Fig. 54. Ventral view of the abdomen of female.  $\times 5$ .

Fig. 55. Dorsal view of the 1st abd. appendage of right side.  $\times 12$ .

(Seen as an opaque object.)

En. gr., main entrance groove.

Sc. cu., sculptured cuticle.

Sp gr., special entrance groove.

Fig. 55a. Dorsal view of the 2nd abd. appendage of right side.  $\times 12$ .

(Seen as an opaque object.)

Fig. 56. Dorsal view of the 3rd abd. appendage of left side.  $\times 12$ .

(Seen as a transparent object.)

Underlying parts (e.g., aff.c., the afferent canal of Endopodite) shown by a broken line.

Fig. 57. Part of a longitudinal section through the abdomen.  
× 25.

Only the details of the first three appendages are shown.

ri., transverse ridge.

Aff. bl., afferent blood canal passing through the protopodite bounded by intermediary tissue.

Sc. cu., sculptured cuticle. The limits of this can be seen.

The section of the 3rd appendage passed through the place of articulation of the exopodite and protopodite. The endopodite, therefore, does not show the afferent canal in section. See AB in Fig. 56 for line of section.

#### PLATE XVI.

##### *Platyarthrus hoffmannseggii.*

Fig. 58. Ventral view of the abdomen of female. × 15.

Fig. 59. Longitudinal section through the abdomen. × 45.  
Arrangement of appendages and parts as in the other sections of similar kind.

Fig. 60. Dorsal view of the 3rd abdominal appendage of left side. × 50.

(Seen as transparent object.)

Fig. 61. Part of a longitudinal section of the third abdominal appendage such as along the line AB in Fig. 60.  
× 150.

Fig. 62. Two tubercles from edge of telson. They are drawn as they appear from above, as transparent objects. The figure also shows the cuticle with its shallow polygonal cavities.

##### *Ligia oceanica.*

Fig. 63. Ventral view of abdomen of female. × 3.

Fig. 64. Dorsal view of 1st abdominal appendage of right side. × 7.

(Seen as transparent object.)

Pr<sup>1</sup>, proximal division of Protopodite showing the muscles within.

Pr<sup>2</sup>, distal division of same containing blood vessels.

Ex., Exopodite showing afferent (aff.) and efferent (eff.) vessels.

Fig. 65. Dorsal view of 2nd abdominal appendage of right side.  $\times 7$ .

Pr., Protodopodite with large outer lobe, lo.

En., Endopodite.

Ex., Exopodite with afferent and efferent vessels.

#### PLATE XVII.

##### *Ligia oceanica* (continued).

Fig. 66. Ventral view of 3rd abd. appendage of left side.  $\times 7$ .

(As transparent object with Endopodite omitted.)

The Exopodite shows the circulation.

aff., the afferent vessels, ventral.

eff., the efferent vessels, dorsal.

Fig. 67. Dorsal view of the 3rd abd. appendage of left side.  $\times 7$ .

Exopodite shown in outline.

Endopodite with small portion showing details.

Fig. 68. Transverse section of the 3rd Exopodite. Only a small part shown, to illustrate the pillars.  $\times 150$ .

d. bl. v., dorsal blood vessels (efferent system).

v. bl. v., ventral blood vessels (afferent system).

v. bl. c., special ventral blood cavity for respiratory purposes.

Ep. d., Ep. v., epithelium of dorsal and ventral walls.

In., intermediary tissue.

In. sp., special layer of this tissue.

p., pillar. p.v., ventral termination of pillar.

Fig. 69. Another part of an Exopodite in T.S.  $\times 100$ .

References as in Fig. 68.

Here the connection between the ventral cavities and the afferent and efferent systems is shown.

Fig. 70. Part of a transverse section of an Endopodite.  $\times 100$ .

p., pillar; f.p., fibres of pillar attached to cuticle.

Fig. 71. Longitudinal section through the protopodite of the 1st abd. appendage.  $\times 50$ .

Pr<sup>1</sup>, Pr<sup>2</sup>, the two parts of Protopodite.

bl. v., blood vessel.

# A CONTRIBUTION TO THE ORCHIDOLOGY OF TASMANIA.

By

R. S. ROGERS, M.A., M.D., F.L.S.

(Read 14th September, 1931.)

## *Caladenia longii*, Rogers.

Planta gracillima, leviter hirsuta, circa 6.5—15 cm. alta, basi vagina cylindracea membranacea. Folium imperfectum, fere glabrum, longiusculum, angustum, lineare. Caulis gracillimus, paulo infra medium bractea subulata. Flores 1-3, albi vel carnei (?), circiter 2-2.8 cm. in diametro; pedicelli longiusculi, graciles, basi bractea angusta acuta; ovarium angustum, elongatum, glanduloso-hirsutum. Segmenta perianthii subsimilia, extrinsecus glandulosa-hirtella fuscioraque; sepala lateralia elliptica, acuta, patentia, circa 1.2—1.5 cm. longa, 4 mm. lata, 5-7-nervia; sepalum dorsale incurvum, leviter concavum, circa 1.1—1.2 cm. longum, 3 mm. latum, subacutum, lanceolatum; petala falco-elliptica, acuta, 5-nervia, patentia, circa 1.1—1.2 cm. longa, circa 2.5 mm. lata. Labellum unguiculatum, columnam fere aequans, transverse vittatum, 3-lobatum; lobi laterales magni rotundati integri vel a fronte leviter incisi, lobus intermedius triangularis recurvus marginibus pectinatis vel denticulatis; calli 4-seriati, obstipi, anticis brevioribus. Columna erecto-incurvata, superne latiuscule alata, transverse vittata. Anthera breviter mucronata.

Slightly hairy, very slender, about 6.5—15 cm. high, a cylindrical sheath at the base. The leaf incomplete in my specimens, narrow linear, almost glabrous, apparently rather long. Flowers 1-3; pedicels slender, rather long, subtended by a narrow acute bract. Segments of perianth somewhat similar, dusky and glandular—hairy on the outer side; lateral sepals spreading, elliptical, acute, about 1.2—1.5 cm. long, 4 mm. wide, 5-7-veined; dorsal sepal erecto-incurved, slightly concave, about 1.1—1.2 cm. long, 3 mm. wide, subacute, lanceolate; petals falco-elliptical, acute, spreading, 5-nerved, about 1.1—1.2 cm. long, 2.5 mm. wide. Labellum clawed, nearly equal in length to the column, transversely barred, 3-lobed; lateral lobes large rounded entire or slightly notched anteriorly, middle lobe triangular recurved with pectinate or denticulate margins; calli in 4 rows, linear, bent, becoming shorter towards the apex. Column erecto-incurved, rather widely winged above, transversely barred. Anther shortly mucronate.

Tasmania. Railton Hills, North-West Coast. Mr. F. H. Long, 22-10-30.

The flowers are described by Mr. L. Rodway as "pink "to white tinged with red," but when received by me in the dried state they were whitish suffused with violet in the case of one plant and of a deep violet colour in the case of the others.

It belongs to the section *Eu-Caladenia*, and in particular it is related to those members of the section which group themselves around *C. carnea*, R. Br.

The chief characteristics of the new species are to be found in the narrow linear leaf; in the prominent almost entire lateral lobes of the labellum, and in the bent non-clavate linear calli which are arranged in four rows.

The lateral lobes of the labellum readily distinguish it from the *C. testacea* group in which these lobes are ill-defined. Here may be included *C. testacea*, R. Br., *C. angustata*, Lindl., *C. hildæ*, Nicholls, *C. dimorpha*, Fitzg., *C. præcox*, Nicholls. The same character separates it from *C. deformis*, R. Br., and to a lesser extent from *C. cucullata*, Fitzg. The latter has also a very different intermediate lobe with crenate margins and differently shaped calli.

The shape and arrangement of the calli serve to differentiate it from *C. carnea*, R. Br., and its variety (*C. carnea*, var. *aurantiaca*, Rogers) as well as from *C. cærulea*, R. Br. and *C. saccharata*, Rehb. f., in all of which the calli are arranged in two rows on very slender pedicels surmounted by conspicuous globular apices.

The much smaller flowers of *C. iridescens*, Rogers, with their dusky red colour mingled with iridescent golden tints and a middle lobe of the labellum bordered with long clavate glandular calli, are not likely to be mistaken for those of the new species.

In the case of *C. alpina*, Rogers, the broad leaf of the plant and ill-defined lateral lobes of the labellum afford at once a means of separation.

*C. atkinsonii*, Rodway, may possibly prove to be an abnormal form. Under any circumstances its very characteristic labellum which is devoid of calli should easily separate it from *C. longii*, Rogers.

With the two Western Australian species *C. paniculata*, Fitzg., and *C. purdieana*, Andrews, no confusion should arise, as both these plants possess paniculate inflorescences as well as marked structural differences in the flowers.

*HYMENOPHYLLUM MINIMUM*, A. Rich.

By

L. RODWAY, C.M.G.

(Read 12th October, 1931.)

This rare little fern has lately been found in Tasmania by Mr. Long, of the Museum staff. It is the smallest of our Filmy Ferns, and is doubtfully distinct from *Hymenophyllum tunbridgense*. Its rhizome is wiry and dry, and sustains few fan-like branches, green and delicate, each of about 1 cm. diameter. The noticeable feature as distinct from *H. tunbridgense* is that the spines on margins and sporangia are reduced to a minimum.

## THE EXTINCT TASMANIAN EMU.

By

H. H. SCOTT,

Curator of Queen Victoria Museum, Launceston.

(Read 27th July, 1931.)

In a former communication to this Society, which was read on 8th October, 1923, dealing in part with the extinct King Island Emu, I gave, *inter alia*, some notes upon such Tasmanian Emu bones as had been to that date added to our Museum Collection.

Since then two other finds have reached us, and will now be passed in review.

## THE SMITHTON FIND.

From an old contributor to our palæontological series of vertebrate remains—Mr. Tom Edwards—there came to us in October, 1924, a synsacrum, 1 femur, 1 tibio-tarsus, 2 tarsal-metatarsi, and 1 cervical vertebra of a Tasmanian Emu recovered from Mowbray Swamp. These were all associated bones absolutely mature, using the word in its true osteological sense—as applicable only to bones whose external texture manifest the highest muscular development and the super-ossification incidental thereto. Everything considered, and having due reference to published notes, I consider this bird to have been a female.

## THE FEMUR.

Greatest length . . . . .	=	225 mm.
Proximal width . . . . .	=	65 mm.
Distal width . . . . .	=	68 mm.
Least girth of shaft . . . . .	=	89 mm.

## THE TIBIO-TARSUS.

Greatest length . . . . .	=	422 mm.
Proximal width . . . . .	=	88 mm.
Distal width . . . . .	=	51 mm.
Girth in centre of shaft . . . . .	=	72 mm.

## THE TARSO-METATARSI.

## RIGHT.

Length . . . . .	=	349 mm.
Proximal width . . . . .	=	55 mm.
Distal width . . . . .	=	55 mm.
Girth in centre of shaft . . . .	=	73 mm.

## LEFT.

Length . . . . .	=	348 mm.
Proximal width . . . . .	=	52 mm.
Distal width . . . . .	=	54 mm.
Girth in centre of shaft . . . .	=	73 mm.

The details of right and left leg bones, thus given, serve the purpose of supplying data respecting bilateral asymmetry.

## THE SYNSACRUM.

As far as my personal knowledge goes this is the only Tasmanian Emu's pelvis available for study, and it, unfortunately, is not perfect. Out of (*circa*) a 400 mm. length, only 270 mm. is represented in the specimen, its depth however—142 mm.—is a correct measurement. The iliac crest is intact for a length of 120 mm., and the proximal articulating centrum is still *in situ*. Distally—and therefore caudad—the mutilation is extensive. The acetabula and both ischiadic foramina are present, but both pubic and ischial processes are lost. A perfect pelvis, in direct comparison with one from an Australian Emu, would, I feel sure, reveal specific variation.

## OSTEOLOGICAL NOTE.

The tarso-metatarsi of this Mowbray Swamp Emu are remarkable for the enormous development of the extensor digitalis grooves, which measured from the tibialis anticus tubercle run a distal course of 240 mm. before they subside upon the shaft. In width, the grooves are proximally 23 mm. wide—9 mm. in the centre—and 14 mm. distally. This ample space for muscular and tendonal lodgment speaks eloquently of the wonderful scratching and digging powers of the bird.

## THE MOLE CREEK FIND.

From Mr. E. W. Clarke, of Mole Creek, we have received a tibio-tarsus of the Tasmanian Emu. This falls into line with our conceptions of the female bird. It is shorter, but mutilation in the item of post-mortem rubbing and grinding accounts for about 12 mm., the remainder coming within the range of individual variation.



## TABLE OF SIZES.

Length (rubbed proximally) ..	=	400 mm. (422 mm.).
Proximal width . . . . .	=	83 mm. (88 mm.).
Distal width .. . . .	=	47 mm. (51 mm.).
Girth in centre of the shaft ..	=	76 mm. (72 mm.).

The figures given in brackets are the dimensions of the Mowbray Swamp bird, added for more direct comparison.

## RECAPITULATIVE.

If the data collected from Mr. Ronald Gunn's specimen—as detailed by me—(*Pro. Roy. Soc. Tas.*, 1923, page 103) be regarded as having reference to the male bird, and the bones just passed in review those of females, then for the first time we have material for estimating the dimensional range incidental to the variation of sex in which the female was slightly smaller than the male bird.

ON THE OCCURRENCE IN TASMANIA OF *HYDROPHIS*  
*ORNATUS*, VARIETY *OCELLATUS*; WITH A NOTE ON  
*PELAMIS PLATURUS* (= *HYDRUS PLATURUS*)

By

E. O. G. SCOTT,

Assistant Curator, Queen Victoria Museum, Launceston.

(Read 27th July, 1931.)

I. *Hydrophis ornatus*, variety *ocellatus* Gray.

In 1927 a sea-snake was captured at Scamander by Mr. K. Gatenby and Mr. Ransom. The animal was subsequently presented to the Queen Victoria Museum, Launceston, by Mr. S. Tulloch Scott; and on making an examination of the specimen last year I came to the conclusion it was *Hydrophis ornatus*, variety *ocellatus* Gray. As the normal habitat of this species is the North Australian Coast (though an individual was caught in the Hawkesbury River, N.S.W., in 1925), the Scamander specimen was submitted to Mr. J. R. Kinghorn, C.M.Z.S., Zoologist, Australian Museum, Sydney, who kindly made an examination of it, and confirmed the determination. This adds a third species to the list of sea-snakes recorded from Tasmanian waters.

Dimensions: Total length, 1,310 mm.; tail, 150 mm.

Reference: Kinghorn, J. R.; "Snakes of Aus." (1929), p. 112.

II. *Pelamis platurus* (= *Hydrus platurus*).

The first specimen of *Pelamis platurus* (= *Hydrus platurus*) recorded from Tasmania was found at Scamander by Mr. J. Stanley Hodgson, and was made the subject of a paper to this Society by Mr. Clive E. Lord, Director, Tasmanian Museum, in 1919. The purpose of this note is to put on record the presence in the collection of the Queen Victoria Museum, Launceston, of a second specimen, captured at St. Helens by Mr. T. Haley (donated 10th February, 1921).

References: (1) (As *Hydrus platurus*), Boulenger, G. A.; Cat. Snakes, Brit. Mus. (1896), Vol. III., p. 267 (page-number misprinted in next reference as "26"); (2) (as *Hydrus platurus*), Lord, Clive E.; *Pap. and Proc. Roy. Soc. Tas.*, 1919, p. 22; (3) (as *Hydrus platurus*), Lord, Clive E., and Scott, H. H.; "Synopsis Vert. Anim. Tas." (1924), p. 109; (4) (as *Pelamis platurus*), Kinghorn, J. R.; "Snakes of Aus." (1929), p. 118.

PRELIMINARY NOTE ON THE SUPPOSED  
ABORIGINAL ROCK-CARVINGS AT MERSEY BLUFF,  
DEVONPORT.

By

E. O. G. SCOTT,

Assistant Curator, Queen Victoria Museum, Launceston.

(Read 21st September, 1931.)

PART 1. INTRODUCTION.

The supposed Tasmanian Aboriginal Rock-Carvings at Mersey Bluff, Devonport, were brought under the notice of this Society by Mr. A. L. Meston, M.A., in a lecture delivered on 20th April, 1931. In conversation, Mr. H. Stuart Dove, F.Z.S., of Devonport, has informed me he has known of the existence of the markings for a number of years, his attention having first been called to them by Mr. Leek about 1914. Mr. Dove has also courteously supplied me with a copy of an article on the subject, illustrated by three figures, contributed by him to *The Australasian* of 15th September, 1923.

As, apart from the present series, no Tasmanian Aboriginal Rock-Carvings, of course, are known, considerable interest was naturally aroused by Mr. Meston's lecture. It was felt that the Queen Victoria Museum, Launceston, being the nearest scientific institution, should acquire, and have available for reference, some first-hand data concerning this important discovery, and I was instructed by the Museum Committee to visit the locality with this object. Accordingly, I spent the afternoon of 24th June, 1931, and the two days following at Devonport, and as a result of my investigation of the supposed carvings formed the opinion that these markings are very probably not of human, but of natural origin.

A paper, based on my Museum Report (which extends to about 100 pages, and includes over 100 figures), and incorporating certain additional data acquired on the occasion of several spare-time visits to Devonport, is in course of preparation and now nearing completion. In view, however, of the considerable length to which this proposed communication has already run, and of the difficulties surrounding the publication of this year's issue of the Society's *Papers and*

*Proceedings*, I have deemed it advisable—reluctant though I am to forego, in particular, the aid of figures—to submit, at the present juncture, merely a short preliminary note on the subject (to which, in preparation for publication, several items have been added).

It must be clearly understood that the present communication is to be regarded, not as a considered statement of the case for the natural origin of the Devonport rock-markings, but merely as a preliminary indication of the chief general lines along which that viewpoint is developed from a considerable body of evidence set forth in the detailed Paper it is proposed, should circumstances permit, to submit at a later date.

I wish to express my sincere thanks to Mr. A. L. Meston, M.A., and Mr. H. Stuart Dove, F.Z.S., both of Devonport, for much courteous assistance and information in connection with the markings; to Mr. D. Mahoney, D.Sc., Director of the National Museum, Melbourne, and Mr. A. S. Kenyon, M.I.E. Aus., for valuable notes on the character of rock-carvings found on the Mainland; to Mr. V. V. Hickman, B.A., B.Sc., for an estimation of the silica-content of the Devonport diabase; to Mr. V. Wellard, of the Mersey Marine Board, for the history of Quarries at Devonport; to Mr. R. Slater, of Kelso, whose hospitality made it possible for me to visit West Head; and to Mr. H. H. Scott, Curator of the Queen Victoria Museum, Launceston, for appreciated assistance in various ways. To the Chairman of the Museum Committee, His Worship the Mayor of Launceston, Alderman F. Boatwright, I am indebted for permission to incorporate in the present communication material from a Departmental Report.

## PART 2. SUMMARY OF ARGUMENTS IN FAVOUR OF HUMAN ORIGIN.

The following summary records the principal considerations that have been, or may be, urged in favour of the human origin of the 75 rock-markings on Mersey Bluff regarded by Mr. Meston as being Aboriginal carvings:—

(1) General shape and character suggestive of human workmanship.

(2) Similar markings found outside Tasmania are of human origin.

(3) Specific imitation claimed for (or names, implying specific and deliberate imitation, bestowed upon) four markings:—(a) Fish; (b) Snake; (c) *Haliotis* Shell; (d) Bird's Head: to which add here, for convenience, (e) Concentric Circles.

(4) Carvings restricted to upper levels of Mersey Bluff headland. Mr. Meston has stated, "I have made a careful search of every headland from Cape Grim to West Head, hoping to find similar work of the aborigines, but have not been successful in finding anything that appears like the carvings at the Bluff; lines and deep markings I have found in plenty, but carvings none."

(5) Carvings restricted to horizontal and subhorizontal rocks.

(6) Difficulty of conceiving any other adequate and available agency.

(7) Outlines never follow natural lines of weakness in the diabase.

(8) All in positions easily accessible to man.

(9) Carvings recognised as being such by observers familiar with Aboriginal rock-carvings in other countries.

(10) Aboriginal midden nearby, among sand-dunes of beach at Western base of the Bluff. On the strength of the supposed restriction of the carvings to the headland, and of the proximity of this midden, Mr. Meston has ventured to suggest that Mersey Bluff may possibly be of special ceremonial significance, in Walker's words, "a place of assembly and consultation."

### PART 3. SUMMARY OF ARGUMENTS IN FAVOUR OF NATURAL ORIGIN.

Though it involves a certain amount of duplication, I summarise separately below, first, the considerations that afford, to a greater or lesser extent, answers to the ten chief arguments in favour of the human theory; and, secondly, the additional independent considerations in favour of the suggestion of natural origin.

#### A. ANSWERS TO ARGUMENTS IN FAVOUR OF HUMAN ORIGIN.

##### (1) *General Shape and Character suggestive of Human Workmanship.*

This, of course, is a principal point in debate. I can here only state that the supposed carvings (considered, for the moment, in complete dissociation from any other rock-

markings, either at Devonport, or elsewhere) seem to me to be more or less definitely unsuggestive of Aboriginal workmanship in the following ways:—

(a) *General Shape* (cases of specific imitation are discussed later). Ovate, pyriform, reniform, and other simple curvilinear outlines are certainly superficially suggestive of human endeavour, but, on the other hand, these outlines are common ones in Nature—persistent annular lichen-transfers, for instance, affording very closely comparable figures, not only as regards general shape and general size, but also as regards details of form (e.g., width of band, spurs, abrupt cessation of outline, secondary loops, etc.), and details of proportion (e.g., ratio of length to maximum breadth; in pyriform examples, relative position of point of maximum width; etc.).

(b) *Depth of Groove*. This reaches a maximum of 54 mm. On the other hand, several of carvings have a maximum depth of less than 5 mm.

(c) *Variation in Depth of Groove in Individual Examples*. Maximum depth of 12 carvings = 10, 3, 3.5, 3, 7, 14, 9.5, 18, 26, 19, 54, 15.75 mm. Minimum depth of same examples = virtually zero, zero, virtually zero, 1, 2.25, 5.5, virtually zero, 1, 3, 2, 5, virtually zero, respectively. In individual examples, the depth changes from 18 to 6.75 mm. in the course of about 25 mm.; from 8 to 1.5 mm. in 5 mm.; from 16 to 4.5 mm. in about 20 mm.; from 22 to 10 mm. in about 4 mm.; from 54 to 25 mm. in about 50 mm.; etc.

(d) *Width of Groove*. The groove varies in width from 2 mm. to 45 mm., or more.

(e) *Variation of Width of Groove in Individual Examples*. Selected instances include:—from 11 to 2; from 13 to 3; from 27 to 6; from 45 to 8; from 20 to 8 mm.

(g) *Cross-section*. Various examples give the following associated measurements of depth and width of groove:—18 mm. (depth) and 8 mm. (width); 16.5 and 6 mm.; 26 and 6 mm. (here, an ordinary lead-pencil, about 7.5 mm. in diameter, even when sharpened to a cone 14 mm. high, cannot be made to reach the bottom of the groove, which is, as noted, just over an inch deep); 18 and 7.5 mm.; 16.5 and 7 mm.; 19 and 8 mm.; 11.25 and 6.5 mm.

The wall of the groove is not infrequently sheer, and occasionally overhanging; and at the same point one wall

may be virtually vertical while the other wall presents a very gradual slope.

At one point in the Snake, the groove is somewhat flask-shaped in vertical cross-section, with a constricted neck following on a mouth 7 mm. across: the groove here is 16.5 mm. deep.

(h) *Small Radii of Curvature of Arcs of Deep Grooves.*

In one case, in a groove 16-19 mm. deep, and 6-8 mm. wide, the rate of curvature is too rapid for a thin steel blade, 9.75 mm. across, at once to follow the outline and keep evenly in contact with the bottom of the groove.

(i) Groove not infrequently undercut at, or near, bottom.

(j) Frequent sudden complete hiatus in outline. Partial interruptions, involving a marked abrupt change in depth and width of groove, also occur.

(k) Common association of cessation of groove, either as hiatus in outline or as free extremity of linear appendage, with a pronounced distal fanning-out.

(2) *Similar Markings Found Outside Tasmania are of Human Origin.*

(a) The markings at Devonport certainly present considerable general resemblance in shape to other rock-markings definitely known to be of Aboriginal origin. They exhibit, however, several characteristic features of outline that are probably, as far as I can ascertain, not duplicated in carvings of, at any rate, Australian workmanship. Unfortunately, I have no first-hand knowledge of the well-known mainland series. Mr. A. S. Kenyon, M.I.E. Aus., however, has very kindly supplied me with much detailed information in answer to a lengthy questionnaire. From this I select the following items that serve to illustrate the marked differences between the Australian Aboriginal carvings and the rock-markings at Mersey Buff:—

- (b) Question. (1) Any recorded examples in diabase?  
(2) In basalt? (3) If "no" to either or both above, any reason, apart from hardness—e.g., lack of rocks?

Answer. "(1) None. (2) None—if [in both cases] 'the query be confined to incised lines: but 'scratched designs have been found on diorite, 'S. Aus., and scratched lines on cylindro-conical

"stones of hard sandstone in a single case. The case of these cylindro-conical stones is typical: all those of soft stone, sandstone, limestone, or slate are incised, those of hard sandstone, etc., are without incisions save the instances above. Stone churingas are all of soft slates."

It may be noted that in a Paper, "Aboriginal Rock-Carvings in South Australia," read before the Australasian Association for the Advancement of Science, at the 1928 Session, Mr. C. P. Mountford records a group of circles and "cup-and-ring" carvings, found on the bank of the Rocky River, about 4 miles south-west from Huddlestons, on a boulder described as being of quartzite. Concerning this boulder, Mr. Mountford says, "It is very likely that a stone of this description would have special ceremonial value." More than 200 carvings, from 14 localities, are described in this Paper, all of them, with the single exception noted, being executed in slate or in "soft Miocene limestone."

(c) Question. Average depth of outlining groove?

Answer. "One centimetre. I have never measured them accurately. Very often with weathering or wearing they are very shallow—2 or 3 mm. or less."

(d) Question. Maximum depth of groove?

Answer. "I do not recollect any two centimetres deep."

(e) Question. Usual form of ogroove in vertical section?

Answer. "The groove may be roughly described as an equilateral triangle in section with a somewhat rounded apex." (Sketch attached.)

(f) Question. Anything like this met with—a groove 26 mm. deep and 6 mm. wide?

Answer. "Not to my knowledge. I have seen many around Port Jackson, the Hawkesbury, in North-West N.S.W., S.W. Queensland, and Northern South Australia."

(g) Question. Ever undercut?

Answer. "No. Decidedly not."

(h) Question. Ever anything like this (sketch of flask-shaped groove-section attached) in vertical section?

Answer. "No."



The marked differences in the character of the groove in the Australian rock-carvings and the markings at Devonport—an aspect I conceive to be of primary importance—will be realised on comparing the notes above with the data recorded in the preceding section.

(3) *Examples of Supposed Specific Imitation.*

In so far as they can readily be summarised, the chief points of criticism of the examples of supposed specific imitation are as follows:—

A. *Fish.*

- (a) Unconvincing outline—called by other observers “Leaf” and “Owl.”
- (b) No fins.
- (c) Two large irregular series of pits (max. d = 16 mm.) in head region apparently not representatively significant.
- (d) Inwardly projecting spur (l = 72 mm.) in head region apparently not representatively significant.
- (e) “Tail,” unlike rest of body, not outlined by a groove, but is itself a single depression.
- (f) Variation in depth of groove. Depth at 37 points (successive, but not equidistant) = 18, 6.75, 8, 1, 6, 5, 7, 1, 5, 5, 0.5, 0, 3, 1, 2, 3, 1, 2.5, 3.5, 1, 9, 5, 8.25, 5, 9, 8, 5, 13.5, 18, 10, 11, 6, 8, 2, 3.5, 1.5, 8 mm. The depth changes from 18 to 6.75 mm. in about 25 mm., and from 8 to 1.5 mm. in 5 mm.
- (g) Variation in width of groove. Width at the 37 points whose depth-measurements are noted above = 21, 16, 24, 20, 20, 18, 24, 14, 22, 17, 10, 0, 18, 7, 10, 16, 6, 18, 15, 13, 26, 24, 25, 27, 25, 22, 21, 23, 23, 24, 23, 19, 16, 10, 15, 8, 17 mm. The width changes from 18 to 7 mm. in about 20 mm., and from 17 to 8 mm. in 5 mm.
- (h) In deeper head-region, outer wall of groove comparatively sheer, inner wall very gradually sloping.
- (i) Anteriorly, outer wall slightly undercut.
- (j) Outline barely traceable for a stretch of about 43 mm.

- (k) Outline duplicated by crustaceous lichens.
- (l) Fish-like intaglio ( $l = 162$ ;  $b = 38$ ; max.  $d = 12$  mm.) in recently worked diabase quarry at West Devonport.
- (m) Fish-like intaglio ( $l = 170$ ;  $b = 70$ ; max.  $d = 16.5$  mm.) in diabase on right bank of Mersey, some 2 or 3 miles from Bluff.
- (n) Fish-like outline ( $l = 232$ ;  $b = 112$ ; max.  $d = 8.5$  mm.) in diabase near West Tamar Road, Launceston.
- (o) Small size of carving ( $l$ , between parallels  $= 328$ ;  $w = 160$  mm.); outlined representations of fish in Australian Aboriginal carvings usually being very large (up to 30 feet long).
- (p) Ratio of length to breadth in carving is 328 to 160 mm. (i.e., 2.05), and in example mentioned in note (n) is 232 to 112 mm. (i.e., 2.07).

#### B. *Snake.*

- (a) Unconvincing outline (head outlined by groove; tail itself a groove; one large and three small internal independent elements).
- (b) Numerous scattered shallow depressions to immediate left of carving, and two isolated shallow arcs, one outside upper right, other outside and subparallel with lower right, corner.
- (c) Variation in depth of groove. Thirteen measurements of depth (at non-equidistant intervals)  $= 3, 2, 10, 18, 18.5, 19, 16.5, 11.25, 4.5, 9, 14.5, 9.5, 7$  mm.
- (d) Variation in width of groove. Width at the 13 points whose depth-measurements are noted above  $= 6, 5, 6, 7.5, 11, 8, 7, 6.5, 7, 8, 11, 7, 15$  mm.
- (f) A depth of 16.5 mm. associated with a width of only 7 mm., and a depth of 18 mm. associated with a width of only 7.5 mm.
- (g) Groove undercut in 5 separate regions, one of which is 35 mm. long.
- (h) Walls of groove often comparatively sheer.
- (i) Vertical cross-section of groove, at lower left corner, flask-shaped (7 mm. wide at "mouth"; 16.5 mm. high).

- (j) Groove in diabase at Cataract Hill, Launceston, forming only 3 sides of a rectangle, is 92 mm. long (in carving,  $l = 112$  mm.); has completely formed "head," 25 mm. wide (width of "head" in carving = 26 mm.); width of groove varies from 7.5 to about 16 mm.; depth varies from 4 to 16.5 mm.
- (k) Groove below hightide-line at Mersey Bluff presents an outline of same generic character as Snake. Depth at 6 points = 8, 15, 19, 10, 5.5, 3.5 mm. Width of groove at 4 points = 5, 18, 15, 7.5 mm.
- (l) Ratio of length to breadth in carving is 112 to 90 mm. (i.e., 1.24), in example mentioned in note (k) is 95.5 to 70 mm. (i.e., 1.36).

C. *Haliotis* Shell.

- (a) Name applied to one portion only of large, otherwise innominate marking.
- (b) Resemblance is remote (general outline unsatisfactory; presence of spur; etc.).
- (c) From middle of floor of groove, here 40 mm. wide and 35 mm. deep, a large boss rises to a height of 23 mm.
- (d) May possibly be connected with spiral growth-lines in lichens.
- (e) Remainder of carving presents a number of features difficult to reconcile with human theory, e.g., max. d. of groove = 54 mm.; d. of groove changes, in course of about two inches, from 25 to 54 mm.; large basal loops; interruption of outline; large and small independent external elements; large internal spur with distal expansion; three large independent internal elements; etc.
- (f) On same rock are "non-carvings," including a rounded marking, with scalloped outline ( $l = 220$ ;  $b = 200$ ; max. d. = 14.5 mm.); an intaglio ( $l = 121$ ;  $b = 120$ ; max. d. = 27 mm.); an irregular groove ( $l = 730$ ; max. d. = 30 mm.); an intaglio ( $l = 310$ ;  $b = 56$ ; max. d. = 33 mm.); a groove ( $l =$  about 900 mm.;  $b =$  about 51 mm.; this groove, observed on a wet day, contained water to a depth of 97 mm.); etc.

D. *Bird's Head.*

- (a) Resemblance very remote.
- (b) "Eye" apparently a naturally weathered depression, with part of periphery raised as a rim.
- (c) No "eye" in other carvings of generically similar outline.
- (d) Rock-surface flaked away for some distance round anterior portion to a depth comparable with that of the groove.
- (e) Outline closely repeated by lines of pneumatological differentiation and weakness in diabase.

E. *Concentric Circles.*

- (a) Not concentric circles. Consists of the following elements:—(1) a very nearly circular element, interrupted (grooves expanding distally) near "three o'clock," and giving rise to (2) a pointed, outwardly projecting spur near "twelve o'clock"; (3) a less accurately circular element, taking its origin as a pointed groove practically in contact with the end of the spur arising from the inner element, and, apart from a semi-interruption towards "four o'clock," following a course for some distance approximately concentric with that of the inner element, but swinging out noticeably from it towards "ten o'clock," and terminating in a free extremity just before "twelve o'clock"; (4) an inwardly projecting spur arising from the inner element near "eight o'clock"; (5) an outwardly projecting spur arising from the inner element near "ten o'clock"; and (6) a short detached external element at "three o'clock."
- (b) Remarkable combination of skill and inexpertness.
- (c) Near "two o'clock," where outer groove is 8.5 and inner groove is 9.5 mm. below general rock-surface, the narrow region between them is 7.5 mm. below general rock-surface.
- (d) On same rock with this carving, 78 mm. from it, occurs a rectangular marking with secondary rectangular appendage. This marking, which is, so far as I am aware, not regarded as a carving,

is slightly greater in area than the concentric circles, and has a max. d. of 16.5 mm. (max. d. of circles = 15.75 mm.).

- (e) Below high tide line at Bluff occur concentric ovate grooves—outer groove,  $l = 62$ ,  $b = 45$ ,  $w = 2.3$ ,  $d = 1$  mm.; inner groove,  $l = 40$ ,  $b = 25$ ,  $w = 2.3$ ,  $d = 2.5$  mm.
- (f) On headland occur among the “non-carvings” two concentric arcs forming about 1-3 of a broad ellipse; width of groove = 4-5 mm.;  $d = 5$  mm.; chord of inner arc = 85 mm.
- (g) Lichens at Cataract Hill, Launceston, observed forming conspicuous but very shallow concentric circles of erosion. Spurs, projecting inward and outward, present as in carving. Difference between maximum and minimum diameters of carving = 7.2 %; ditto, in the case of 8 lichens (on neighbouring rocks, Cataract Hill) = 3.8, 0.9, 4.1, 6.8, 4.5, 4.1, 10.3, 3.1 %; av. = 4.7 %.

#### 4. *Supposed Restriction to Upper Levels of Bluff.*

(a) A carving ( $l = 265$ ;  $b = 195$ ; max. d. = 49 mm.), more striking than 90 % of those at the Bluff, occurs on a rock (below high tide-line) about 11 yards southward from the retaining wall at the Western end of Devonport Bridge, some 2 miles from the Bluff.

(b) Other examples (up to 30 mm. deep) occur on both banks of the Mersey above the Bridge.

(c) At, and below, high tide-line at Mersey Bluff (particularly on N.W. aspect) are numerous grooves of ovate, pyriform, reniform, and other outlines. Dimensions of 6 examples ( $l$  and  $b$  = external length and breadth;  $w$  = average width of groove;  $d$  = maximum depth):—(1) ovate, with curved terminal appendage,  $l$  (with appendage) = 115,  $b = 54$ ,  $w = 6$ ,  $d = 25$  mm.; (2) ovate, with transverse internal groove, 5.5 mm. deep,  $l = 50$ ,  $b = 43$ ,  $w = 9$ ,  $d = 5.5$  mm.; (3) pyriform,  $l = 60$ ,  $b = 35$ ,  $w = 6$ ,  $d = 24$  mm.; (4) reniform,  $l = 95$ ,  $b = 59$ ,  $w = 5$ ,  $d = 24$  mm.; (5) rectangular,  $l = 196$ ,  $b = 196$ ,  $w = 40$ ,  $d = 56$  mm. (or more); (6) pyriform, with subsidiary internal loop,  $l = 92.5$ ,  $b = 68$ ,  $w = 2$ ,  $d = 4$  mm.

These markings are closely comparable in size and general shape with corresponding members of the carving-series, and exhibit similar characteristic curved appendages,

transverse internal grooves, internal subsidiary loops, detached elements, bosses rising from floor of groove, interrupted sections, and so on.

In some cases the groove, particularly apically in ovate examples, has formed (up to a depth of 22 mm.) immediately beneath an overhanging hood-like lamina of diabase, which, on being removed (readily enough) by the fingers, exposes the groove.

(d) On vertical faces of diabase-quarries (6-15 feet above general ground level) at East and West Devonport, worked recently, certainly within the last 20 years, occur, among others, the following well-marked grooves:—(1) ovate,  $l = 60$ ,  $b = 49$ ,  $w = 10$ ,  $d = 4$  mm.; (2) pyriform,  $l = 190$ ,  $b = 89$ ,  $w$  at 5 points = 14, 27, 11, 18, 30 mm.;  $d$  at same points = 3.25, 7.5, 5.25, 3.5, 7.75 mm.; (3) ovate,  $l = 88$ ,  $b = 75$ ,  $w = 10-20$ ,  $d = 8$  mm.; (4) reniform,  $l = 105$ ,  $b = 53$ ,  $w =$  about 8,  $d = 6$  mm.; (5) fish-like intaglio,  $l = 162$ ,  $b = 38$ ,  $d = 12$  mm.; (6) ovate,  $l = 40$ ,  $b = 30$ ,  $d = 6$  mm. Examples (2), (5), and (6) occur in much-weathered diabase in the Mersey Marine Board's Quarry, first worked, Mr. V. Wellard informs me, in 1912. Examples (1), (3), and (4) are from Mr. Coulter's Quarry at East Devonport, and occur on a face almost certainly opened up during the present century.

(e) Wherever I have been able to examine diabase formations, I have found grooves in the shape of closed curves. These are at once much rarer, and, on the average, much shallower than the Devonport examples. It is, I think, a matter of considerable importance to observe that the unclosed curves, or "non-carvings" are correspondingly rarer and correspondingly shallower than the non-carvings on the Bluff (see section (6)). Notes on 6 selected examples:—(1) Cataract Gorge; ovate with terminal appendage;  $l = 88$ ,  $b = 70$ ,  $w = 9-15$ ,  $d = 8$  mm.; (2) Cataract Gorge; pyriform;  $l = 115$ ,  $b = 72$ ,  $w = 11-14$ ,  $d = 4$  mm.; (3) Ravenswood; pyriform with rectangular appendage;  $l =$  about 145,  $b = 74$ ,  $w = 4-11$ ,  $d = 6.5$  mm.; (4) West Head; pyriform;  $l = 136$ ,  $b = 64.5$ ,  $w = 5-9$ ,  $d = 2$  mm.; (5) West Head; pyriform;  $l = 48$ ,  $b = 24.5$ ,  $w = 5.5-10$ ,  $d = 5$  mm.; (6) Waverley, Launceston; ovate with interrupted outline;  $l = 60$ ,  $b = 43$ ,  $w = 4.5-12$ ,  $d = 5.5$  mm. (This last example is more clearly and boldly cut, and decidedly more striking than several of the poorer, small supposed carvings of similar character.)

(5) *Supposed Restriction to Horizontal and Subhorizontal Surfaces.*

(a) Area on headland of Mersey Bluff on which the carving-series occurs consists chiefly of horizontal and sub-horizontal rocks.

(b) Both carvings and non-carvings are in general restricted to these.

(c) At least one carving does occur partly on a sloping and partly on a subvertical face. Further investigation is needed.

(d) The place of both the carvings and non-carvings at Devonport is apparently taken on vertical rock-faces by pronounced exfoliations of comparable size and shape.

(e) In localities other than Devonport the grooves in the diabase are usually, but not exclusively, on the horizontal, and the exfoliations chiefly on the vertical faces.

(6) *Difficulty of Conceiving any other Adequate and Available Agency.*

(a) *As regards shape.* The characteristic shapes of the supposed carvings are duplicated in whole or in part by numerous small outlines scratched on the rock-surface at Devonport and elsewhere as finely as if incised by a needle; by the grooves found below the tide-line at Devonport (section 4 (c)); by grooves in recently worked quarry-faces at Devonport (section 4 (d)); by grooves in diabase in localities other than Devonport (section 4 (e)); by extensive exfoliations on vertical diabase-faces at Devonport and elsewhere; and in many cases with great fidelity by rock-lichens.

(b) *As regards depth and character of the groove.* Scattered about the area on the Bluff headland in which the carvings occur, and often on the same rocks with them, are numerous other well-defined grooves, usually with unclosed outlines, and intaglios. As Mr. Meston's restriction of his list of carvings to 75 examples indicates, these markings are not regarded by him as being of Aboriginal origin. For convenience, I designate them non-carvings. Some measurements of non-carvings appear below.

(c) *Length.* From a few mm. to, e.g., about 900, 950, 780, 430, 240, 310 mm.

(d) *Depth of groove.* Measurements of maximum depth include:—33, about 100, 38, 27, 40, 33, 24.5, 31.5 mm.

(e) *Variation of Depth of Groove in Individual Examples*:—(1) from 4.5 to 1 mm.; (2) from 21 to 6 mm.; (3) from 11 to 3.5 mm.; (4) from 20 to 5.5 mm.; (5) from 18.75 to 2 mm.; (6) from 14.5 to 0 mm.; etc. Often abrupt changes in depth, e.g., from 10 to 0 mm., from 13.75 to 3.5 mm., from 5.5 to 3 mm., from 31.5 to 6 mm., in the course of a few mm.

(f) *Width of Groove*. Varies from 1 or 2 mm. to 82 mm. or more.

(g) *Variation of Width of Groove in Individual Examples*:—(1) from 18 to 8 mm.; (2) from 26 to 11 mm.; (3) from 35, or more, to 6 mm.; (4) from 51 to about 8 mm.; (5) from 82 to 35 mm.; (6) from 56 to 40 mm.

(h) *Cross-Section*. Various examples give the following associated measurements of depth and width of groove:—(1) 14.5 (depth) and 10 mm. (width); (2) 31.5 and 11 mm.; (3) 22 and 13 mm.; (4) 40 and 17 mm.; (5) 19 and 8 mm.; (6) 19.5 and 5 mm. Wall may be sheer, overhanging, or gradually sloping. One example, 31.5 mm. deep, 11 mm. wide, is somewhat flask-shaped in vertical cross-section.

(i) Some deep grooves have a comparatively small radius of curvature.

(j) Undercut in a number of cases.

(k) Complete and partial interruptions in outline occur.

(l) Common association of cessation of groove, either as hiatus in outline or as free extremity, with a pronounced distal fanning-out.

(m) These grooves are not, nor, I think, plausibly can be, claimed as being of Aboriginal origin. The agency responsible for their incision would be capable, in so far as depth and general character of the groove are concerned, of incising the grooves of the supposed carvings.

(n) Lichens, which are sometimes very long-lived, have been known to eat into rock to a depth of 30 mm. Lichens have been known to eat into glass, and a determination kindly made for me by Mr. V. V. Hickman, B.A., B.Sc., shows that the Devonport diabase has a silica-content of 46 %. On the other hand, it is to be noted that a much higher percentage of silica occurs in other of our igneous rocks.

(7) *Outlines Never Follow Natural Lines of Weakness in the Diabase.*

(a) It would be somewhat remarkable, from the viewpoint of human theory, if this were so. I have notes and



sketches of lines of weakness forming portions of, and extensions of, the main outline.

(b) In some cases cracks or furrows run on to, or right across, the carving, maintaining their own integrity while traversing the groove. If the supposed carvings are of human origin, these cracks must be of subsequent formation. It is of interest to observe that similar furrows maintain their integrity in depressions and grooves formed by crustaceous lichens.

(8) *All in Positions Easily Accessible to Man.*

(a) All the markings recognised as carvings are accessible to man. (Further investigation on this point is desirable.)

(b) Some examples are in decidedly awkward situations.

(c) Of the markings here noted from below the tide-line at Mersey Bluff, some (e.g., those with large lamellar hoods overhanging the groove) are not accessible by Aboriginal implements.

(d) Grooves here noted from quarry-faces at Devonport, opened up within the last 20 years or so, are not accessible to Tasmanian Aborigines.

(9) *Carvings Recognised as Being Such by Observers Familiar with Aboriginal Rock-Carvings in Other Countries.*

In a summary such as the present, it can merely be said that other observers, similarly qualified, hold an opposite opinion.

(10) *Aboriginal Midden nearby, among Sand-dunes of Beach at Western Base of Bluff.*

(a) Aboriginal middens found at frequent intervals along practically the whole Northern Coast of the Island.

(b) Carvings not restricted to Mersey Bluff.

B. ADDITIONAL ARGUMENTS IN FAVOUR OF NATURAL ORIGIN.

In the preceding sections (Part 3; A; Nos. 1-10) a general answer to the chief arguments in favour of the human theory has been outlined. The formulation of this reply has naturally involved the general statement of a large part of the case for the natural origin of the markings; and the opportunity has been taken to draw attention to several points (e.g., occurrence of deep curvilinear grooves in diabase below the tide-line and in quarries) that may perhaps best be regarded not merely as answers to arguments for the Aboriginal theory, but as independent considerations in favour of the suggestion of natural origin.

Additional independent considerations — of varying evidential weight—in favour of the theory of natural origin include the following:—

(11) In many of the ovate examples below the tide-line at Mersey Bluff the whole area enclosed by the groove is elevated into a knob (a structure, I presume, probably allied to that of orbicular Websterite), usually rising a few mm., but at times as much as 800 mm., above the general surrounding surface. On re-examining the ovate carvings on the headland, I found that in a number of instances a ruler balanced on the central portion of the area enclosed by the groove rode quite clear of (in marking on same rock with snake 3-4 mm. above) the general surrounding surface.

(12) Absence from the known range of Tasmanian Aboriginal implements of a tool capable of incising grooves of such character. (See details of depth, width, and cross-section of groove in section (1).) It may be observed that a neatly scratched modern design at the Bluff (comprising an approximately equilateral triangle, two initials, and the figures 66), in which the tool-marks are visible, has a maximum depth of 1.75 mm., and an average depth of 1 mm. or less.

(13) Though there is no constant ratio between size of outline and depth of groove, the deeper grooves occur in general in the larger markings. The largest marking of the series is notably the deepest.

(14) The deeper grooves, among both the carvings and the non-carvings on the headland, are found on the Northern and North-Western (i.e., the most exposed) aspects of the Bluff.

(15) Though personally I attach little weight, from an evidential point of view, to such a negative consideration, it appears, on the face of it, surprising that the refractory igneous diabase should be selected for the incision of carvings to the complete neglect, as far as is known, of the readily accessible softer sedimentary rocks (e.g., slates, and the Midland sandstones).

(16) Some evidence is available of the formation of fairly pronounced curvilinear grooves in concrete, cement, and dressed freestone. Further investigation is needed.

(17) The Tasmanian diabase exhibits in great number curves of pneumatological differentiation closely comparable in area and outline with the typical carvings, the resemblance extending even to the minor features of proportion and form.

These areas of differentiation may manifest themselves as (a) mere superficial outlines of segregation, or, after being acted upon by weathering agencies, as (b) grooves, (c) exfoliations and intaglios, (d) lines or curves in relief.

(a) Example. Dimensions of regular pyriform carving, with corresponding dimensions of regular pyriform superficial segregation—outline (Cataract Hill, Launceston) in brackets for comparison (all measurements internal):— $l = 140$  mm. (196 mm.);  $b = 75$  mm. (114 mm.); max. breadth expressed as a percentage of length = 54 % (58 %); vertical distance of max. breadth from top (i.e., broader end) expressed as a percentage of length = 25 % (26 %).

(b) Grooves. See Part 3; section 6.

(c) Exfoliations. I possess specimens from Devonport and elsewhere, all detached by the finger-tip. Dimensions of an ovate example (Trevallyn, Launceston):— $l = 189$  mm.;  $b = 117$  mm.; max. d. = 33 mm.; wt = 2 lbs. 2½ oz.: larger specimens are obtainable.

These exfoliation-flakes *in situ* and the intaglios formed by their weathering-out are exceedingly common, particularly on vertical and subvertical faces. It may be of interest to mention here that while on a visit to West Head, M. Landgraff, Mr. T. Slater, and myself discovered in the Cambrian or Pre-Cambrian schists, between Kelso and West Head, an extraordinary series of deep and very clearly defined water-worn intaglios, the smaller and more numerous members of which exhibit a striking resemblance to a human footprint.

(d) At, and below, the hightide-line on the N.W. of Mersey Bluff, outlines comparable in shape and size with those of the common carvings are raised in appreciable, sometimes in high, relief. Occasional curves in relief occur also on the headland itself.

(18) Complete absence at Devonport, so far as I am aware, of the track-marks that form such an important element in the great majority of extensive series of Australian Aboriginal rock-carvings.

(19) In conversation, Mr. Meston has informed me that in the period of less than three years during which he has observed the markings five examples of his original list of eighty have weathered out. Mr. Dove tells me also that of the three examples figured by him in *The Australasian* in 1923 one is now nearly indecipherable.

## PART 4. CONCLUSION.

As a personal opinion, based on the evidence available, I have very little doubt indeed that the 75 rock-markings at Mersey Bluff claimed by Mr. Meston to be carvings are not of Aboriginal origin. I regard them as being striking, but somewhat arbitrarily selected, items in an extensive series of natural erosions.

As regards the mode of formation, the data collected would seem to show that the erosion has in general occurred along lines of inherent pneumatological weakness in the Mesozoic diabase. There is some reason to believe that, in addition to inorganic weathering-agencies, rock-lichens have played a not unimportant part in the process of erosion of the grooves, and in some cases it is possible they have initiated the groove.

It has already been observed that the present communication does no more than form an outline of the general trend and scope of the chief objections to the theory that these rock-markings are of Aboriginal workmanship. It is proposed, should it prove expedient, to make a detailed examination of the problem the subject of a later paper. In the meantime, the case for the natural origin of the supposed carvings merits, I think, serious consideration.

# THE ROYAL SOCIETY OF TASMANIA

1931

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## ABSTRACT OF PROCEEDINGS, LIST OF MEMBERS, &c.

On account of the elimination of the Government Grant-in-aid of Printing, and the general economic depression, the Abstract of Proceedings and List of Members are omitted, and the Report printed in abstract only.

The Council regrets that present circumstances render it necessary to reduce the annual volume, but the present financial position is a matter of grave concern to the Council.

# THE ROYAL SOCIETY OF TASMANIA

## ANNUAL REPORT, 1931

(ABSTRACT.)

The Annual Meeting was held on the 16th March, 1931. The following were elected as Members of the Council for 1931:—Dr. A. H. Clarke, Mr. W. H. Clemes, Dr. W. E. L. Crowther, Mr. E. T. Emmett, Dr. A. N. Lewis, Mr. L. Rodway, Mr. J. Reynolds, Mr. E. E. Unwin, Mr. F. E. Ward, and Mr. C. Lord (*ex officio*).

Mr. W. E. Taylor was elected Honorary Auditor.

The Council at its first meeting made the following appointments:—

Chairman—Mr. W. H. Clemes, B.A., B.Sc.

Secretary—Mr. Clive Lord.

Standing Committee—Messrs. Clemes, Lord, and Dr. Lewis.

Trustees of the Tasmanian Museum and Botanical Gardens—Drs. Clarke, Crowther, Lewis, Messrs. Clemes, Emmett, and Unwin.

### *Meetings.*

Ten meetings were held, at which a number of valuable papers were read and lectures given.

### *Finance.*

The total withdrawal of the Government grant has thrown the Society entirely on its own resources, with the result that the maintenance of the Library and the printing of the proceedings of the Society has entailed a heavy tax on the Society's resources.

*Papers and Proceedings.*

The printing of the Papers and Proceedings for the year 1931 has been delayed owing to financial considerations, but it is hoped to publish the volume in the near future.

*Natural Sciences.*

The Council of the Society, being of the opinion that it is urgently necessary for the well-being of the State of Tasmania that greater facilities be afforded for the study of and education in the natural sciences, took steps to bring the matter under the notice of the Government, with the result that the Honourable Minister for Education arranged a conference, and a Committee has been appointed to bring up a report.

*Rodway Herbarium.*

The Society interested itself in assisting the Trustees of the Tasmanian Museum to purchase the Rodway Herbarium, and the splendid response made by Members of the Society and others enabled this most valuable collection to be retained in the State.

*Branches and Sections.*

The Northern Branch and the several sections of the Society continued their activities in a satisfactory manner.

*General.*

Owing to the Secretary (Mr. Lord) visiting England as one of the Australasian Delegates to the Centenary Meeting of the British Association, Mr. E. T. Emmett acted as Honorary Secretary for six months, and it is desired to place on record the Society's appreciation of his services.

*Obituary.*

It is with regret that the Society has to record the death of the following Members:—

Professor Alexander McAulay.

Mr. A. W. Courtney Pratt.

Mr. Alan C. Walker.

## BRANCH REPORTS

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### NORTHERN BRANCH.

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#### ABSTRACT REPORT.

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The following were elected as Members of the Council of the Northern Branch for 1931:—Hon. T. Shields, M.L.C. (Chairman), Messrs. F. Heyward, F.R.V.I.A., W. R. Rolph, R. S. Padman, D. V. Allen, B.Sc., F. Smithies, J. R. Forward, R. A. Scott, and E. O. G. Scott (Hon. Secretary).

Five meetings were held during the year, and several interesting and instructive lectures were given. In addition, certain papers were read and discussions held. Generally, the Branch has had a successful year.

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## SECTION REPORTS

The only section in active operation was the Educational Section. Neither the Historical nor the Botanical Section held meetings.



# THE ROYAL SOCIETY OF TASMANIA.

## STATEMENT OF ACCOUNTS FOR THE YEAR ENDED 31/12/31.

### GENERAL FUND.

RECEIPTS.			EXPENDITURE.		
	£	s. d.		£	s. d.
Balance Brought Forward .. .. .	11	6 7	Salaries .. .. .	39	0 0
Subscriptions .. .. .	217	7 0	Papers and Proceedings, 1930 (Part) .. .	110	0 0
Receipts, Special Meetings .. .. .	29	5 11	Cost of Meetings, Notices, Advertising, and		
Rent of Room .. .. .	26	3 0	General Printing .. .. .	84	9 5
Miscellaneous .. .. .	6	14 4	Library .. .. .	14	4 1
			Insurance .. .. .	5	18 9
			Light and Fuel .. .. .	4	0 10
			Miscellaneous .. .. .	5	9 5
			Postages and Petty Cash .. .. .	13	0 0
			Credit Balance Carried Forward .. .. .	£276	2 6
				14	14 4
				£290	16 10

Examined and certified to be correct,

WALTER E. TAYLOR,

Hon. Auditor.

19/2/32.

JOHN REYNOLDS, Hon. Treasurer.  
CLIVE E. LORD, Secretary.

14/1/32.

# THE ROYAL SOCIETY OF TASMANIA.

## R. M. JOHNSTON FUND.

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R. M. JOHNSTON MEMORIAL.



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# The Royal Society of Tasmania





PAPERS & PROCEEDINGS  
OF  
THE ROYAL SOCIETY  
OF TASMANIA

FOR THE YEAR

1932



(With 23 Plates and 1 Text Figure)

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# The Royal Society of Tasmania

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The Royal Society of Tasmania was founded on the 14th October, 1843, by His Excellency Sir John Eardley Eardley-Wilmot, Lieutenant-Governor of Van Diemen's Land, as "The Botanical and Horticultural Society of Van Diemen's Land." The Botanical Gardens in the Queen's Domain, near Hobart, were shortly afterwards placed under its management, and a grant of £400 a year towards their maintenance was made by the Government. In 1844 His Excellency announced to the Society that Her Majesty the Queen had signified her consent to become its patron; and that its designation should thenceforward be "The Royal Society of Van Diemen's Land for Horticulture, Botany, and the Advancement of Science."

In 1848 the Society established the Tasmanian Museum; and in 1849 it commenced the publication of its "Papers and Proceedings."

In 1854 the Legislative Council of Tasmania by "The Royal Society Act" made provision for vesting the property of the Society in trustees, and for other matters connected with the management of its affairs.

In 1855 the name of the Colony was changed to Tasmania, and the Society then became "The Royal Society of Tasmania for Horticulture, Botany, and the Advancement of Science."

In 1860 a piece of ground at the corner of Argyle and Macquarie streets, Hobart, was given by the Crown to the Society as a site for a Museum, and a grant of £3000 was made for the erection of a building. The Society contributed £1800 towards the cost, and the new Museum was finished in 1862.

In 1885 the Society gave back to the Crown the Botanical Gardens and the Museum, which, with the collections of the Museum, were vested in a body of trustees, of whom six are chosen from the Society. In consideration of the services it had rendered in the promotion of science, and in the formation and management of the Museum and Gardens, the right was reserved to the Society to have exclusive possession of sufficient and convenient rooms in the Museum for the safe custody of its Library, and for its meetings, and for all other purposes connected with it.

In 1911 the Parliament of Tasmania, by "The Royal Society Act, 1911," created the Society a body corporate by the name of "The Royal Society of Tasmania," with perpetual succession.

The object of the Society is declared by its Rules to be "the advancement of knowledge."

His Majesty the King is Patron of the Society; and His Excellency the Governor of Tasmania is President.



# The Royal Society of Tasmania

## Papers and Proceedings, 1932

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# Papers of The Royal Society of Tasmania 1932

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## ABORIGINAL ROCK CARVINGS IN TASMANIA.

### PART II.

By

A. L. MESTON, M.A.

Plates I-IV.

(Read 10th October, 1932.)

On the 13th of July last year I read a paper before the Society in which I described some aboriginal rock carvings on the Mersey Bluff, near Devonport. In this paper I propose to describe another series of aboriginal carvings. These I discovered in December, 1931, on the west coast, 90 miles, as the crow flies, from those at Devonport.

These carvings are not only intensely interesting in themselves, but are important, in that they provide further evidence of aboriginal art. In many respects they differ from those near Devonport. The latter are in diabase, are cut on horizontal faces, and in the main exist as units; whereas the west coast carvings are in a friable calcareous sandstone, are cut without any respect to the surface plane, and are massed together, sometimes in rude geometric designs.

Twelve miles south of Cape Grim there projects into the sea a massive diabase headland, which, although only a little more than 500 feet high, rising, as it does, out of a country of low elevation, is so prominent a feature that it is called Mount Cameron West. Two miles north of this landmark are the two outcrops of friable calcareous sandstone, 150 yards apart, small in area, and of low elevation, on which the carvings are found. The rock is soft and easily worked, but hardens on contact with the air. In consequence of its friable nature many of the carvings are badly weathered, and all show marks of erosion. The circle,



a common form at Devonport, is here the motif of most of the designs. Here, however, are found features absent from the Devonport carvings, namely, groups of three straight lines roughly parallel with one another, and rows of indentations.

At the southern outcrop the natives have made use, not of the main mass, but of two detached blocks lying at its foot. On these, shown on Plate I., are the most striking of the carvings, which are clearly visible more than 200 yards away. Plate IV. shows the method employed in making them. Indentations or punch-marks are first made close together, apparently with a quartzite burin or punch, driven by a stone used as a hammer; then a continuous line is made by connecting up the holes so formed. A close search for any tools that may have been used in the work resulted in my finding a chisel-shaped piece of quartzite and another pointed stone implement admirably adapted for executing the designs. There is, of course, no evidence except proximity to show that these may have been used.

The northern outcrop, larger than the other, is just a mass of carvings. The cliff face and detached slabs, no matter at what angle they lie, provided there is a smooth surface, have provided a medium for the artist. In the main mass there is a shallow cavern, upon the roof of which, quite out of reach of one standing below, two circles have been carved. These are shown in Plate II., Fig. 1. One mass of approximately 12 feet square, tilted at an angle of about 60 degrees, is entirely covered with circles and concentric circles, some badly weathered, others in a good state of preservation. Some of these are shown in Plate II., Fig. 2.

This district, like the Bluff at Devonport, was a frequent haunt of the natives. The whole area is littered with shells, the remnants of their feasts, and with the cores and rejects from the manufacture of their stone implements. When the aborigines roamed along this shore it was a beautiful spot. Sand-banks covered with boobyallas and other native shrubs extended along the whole area, while immediately behind them were park-like spaces, the pasture ground of mobs of kangaroo. Here they found a place which lay open to the sun, and yet afforded them shelter from the bitter winds. The reefs nearby provided an ample supply of shellfish; the lagoons behind the beach teemed with black swan and wild duck; and the district



*Fig. 1.*



*Fig. 2.*

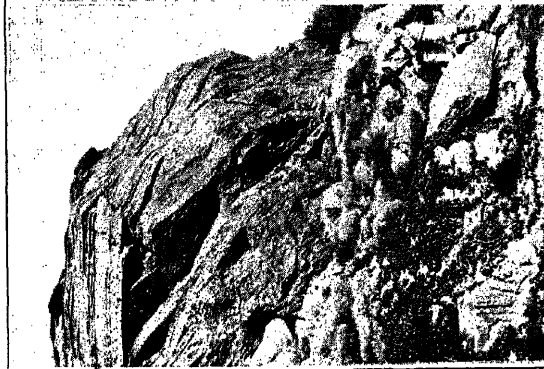


*Fig. 3.*

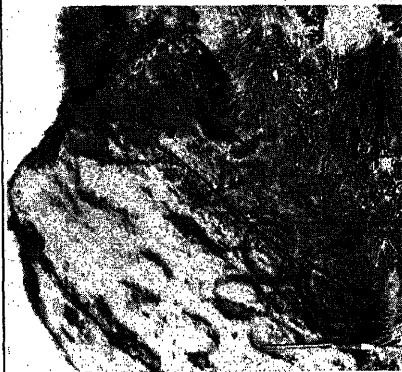


*Fig. 4.*





*Fig. 1.*



*Fig. 2.*



*Fig. 3.*

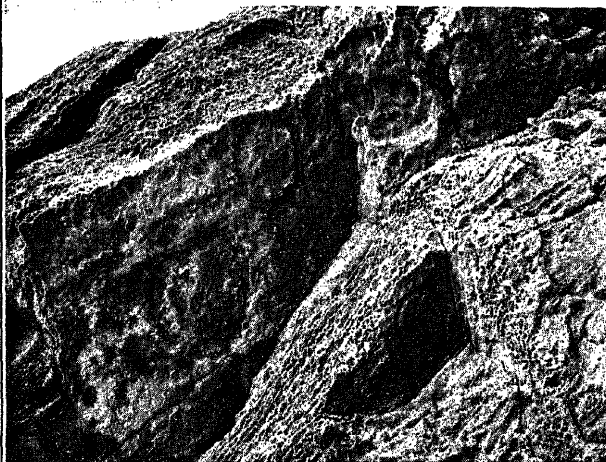


*Fig. 4.*





*Fig. 1.*



*Fig. 3.*



*Fig. 2.*









abounded with wallaby, kangaroo, and opossum. Even to-day, although vast sand-blows, begun by cattle breaking down the banks and allowing the wind free play, have destroyed the face of the country in places for miles inland, the lagoons which are left still teem with wild fowl, and kangaroo, wallaby, and opossum are plentiful in the neighbourhood.

The occurrence of this small isolated sandstone outcrop, totally different in structure from the surrounding rock masses—quartzite to the north, diabase to the south—is remarkable. One feels that to a people in whose lives stones and rocks played such an active part, such an occurrence would be significant. Codrington, who spent twenty-five years in Melanesia, speaks of the superstitious regard for stones commonly shown by the Melanesians, and points out that "stones as they naturally lie," because they strike the fancy as being out of the common, are frequently the object of veneration. It may have been so here in Tasmania, for the opinion of many of the leading anthropologists is that our aborigines were of Melanesian origin.

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#### EXPLANATION OF PLATES.

##### PLATE I.

*Figure 1.*—A general view of the coastline in the vicinity of the carvings, looking north. The figures 3 and 4 on this plate are on the outcrop in the foreground on the extreme right.

*Figure 2.*—A view of the southern outcrop and both carvings, one near the human figure, the other at the foot and to the right of the extreme mass.

*Figure 3.*—This design is on the slab at the left of Fig. 2. When discovered the lower edge was covered with sand. It consists of an irregular figure 102 cms. long and 77 cms. wide, with a median line forming two lobes. The left lobe encloses an irregular circle with diameters of 30.5 cms. and 25.5 cms.; the right lobe encloses one with diameters of 44 cms. and 35.5 cms. The grooves are from 3.25 cms. to 4 cms. wide and 2.5 cms. deep. The edges are abraded by weathering.

*Figure 4.*—This is the most elaborate of the designs, and is on the slab near the human figure shown in Figure 2. A full description appears under Plate IV.

## PLATE II.

*Figure 1.*—A general view of portion of the northern outcrop, showing the shallow cavern and a group of carvings in the left foreground.

*Figure 2.*—This rock face, 3 metres high, looking to the south, is completely covered with circles, most of them badly weathered. This figure shows the two carvings that are best preserved. The lower one consists of two concentric circles, the outer of which has a diameter of 71 cms., the inner of 53.4 cms. Inside the inner ring are two small circles; the left-hand one, 14 cms. in diameter, is made up of 12 punch-marks not connected, which surround a circular boss 9 cms. in diameter; the right-hand one is more irregular, and has diameters of 19 cms. and 11.5 cms. The upper carving is a circle of 46 cms. in diameter. The grooves of both these circles are 5.4 cms. wide. To the right of the lower of these carvings, and not distinctly shown, is an irregular circle with diameters of 46 cms. and 40.6 cms., enclosing a smaller irregular circle with diameters of 17.8 and 14 cms. Another distinct circle on this rock face is 33 cms. in diameter, while another irregular one has diameters of 58.4 cms. and 49.5 cms. Not only the southern face, but the whole mass, wherever it is clear of sand, is covered with circles, most of them badly weathered.

*Figure 3.*—With the exception of the lower left-hand carving, these, while quite distinct, are not so bold in out-

line as the rest. The total length of the irregular carving near the pocketknife is 57.2 cms. The irregular circle enclosed has diameters of 21.5 cms. and 17.8 cms. Close to this is an oval with diameters of 15.2 cms. and 11.4 cms. The wide grooved circle at the bottom has diameters of 31 cms. and 28.5 cms., while the narrow grooved circle at the bottom is 15.2 cms. in diameter. At the head of the irregular-shaped carving, but not shown in the photograph, are three straight lines, 29.2 cms., 33 cms., and 33 cms. in length respectively, meeting a fourth straight line at right angles.

*Figure 4.*—These carvings are on the rock that is shown as being measured in Fig. 1 of this plate. The slab is 102.9 cms. wide, 139 cms. long. Only seven of the ten circles carved on it are shown in this photograph. In the top right-hand corner are three straight lines, 21.5 cms., 22.8 cms., and 30.5 cms. in length respectively, the shortest being at the top. The circle near them has diameters of 36 cms. and 27.9 cms. To the left of this, but outside the scope of the photograph, is another with diameters of 31.7 cms. and 26.5 cms; and immediately below it, but also not shown, is another with diameters of 20 cms. and 15.2 cms. From left to right in this photograph the diameters of the circles are 22.8 cms. and 20.3 cms.; 27.9 cms. and 26.7 cms.; 21.5 cms. and 18.9 cms.; 25.4 cms. and 22.8 cms.; 21 cms. and 16.5 cms.; 25.4 cms. and 20.3 cms. To the right of the lowest one is another of 30.5 cms. and 22.8 cms., but only a small part of it is seen in the photograph. The grooves in these circles vary from 5.1 cms. to 3.8 cms.

### PLATE III.

*Figure 1.*—This is a nearer view of the slab shown in the left-hand corner of Plate II., Fig. 1, and shows how the sand has encroached on the carvings. Note the straight lines.

*Figure 2.*—A view of Mount Cameron West from the site of the carvings.

*Figure 3.*—A nearer view of the carvings on the roof of the shallow cavern. These are not so expertly done as those shown on the rock face (Plate II., Fig. 2). The contrast is remarkable. The lowest of the three circles distinctly shown has diameters of 30.5 cms. and 22.8 cms. The whole of this rock mass is covered with circles almost obliterated by weathering.

## PLATE IV.

The total length of the slab which is entirely covered with the design is 177.8 cms., its greatest width is 142.25 cms., its least width 46 cms. The large irregular circle on the right is broken away at the top and bottom edges, and a large crack, clearly visible in the photograph, has developed, threatening to destroy the mass still further. Its greatest diameter is 91.5 cms., its least 73.6 cms. It encloses another almost perfect circle, 45.7 cms. in diameter, and a number of indentations in rows above the circle. The top row contains 16 indentations, the second 15, and the third 15. Above the fifth in the top row is a single indentation, while below the second in the bottom row is a line of three. To the left of this large circle are three vertical rows of indentations: the right-hand row consists of 19, the middle 11, the left-hand 10. Immediately to the left of these rows is an irregular barred circle with diameters of 55.9 cms. and 46 cms., containing two isolated indentations. Below the vertical row of indentations is another irregular circle with diameters of 35.4 cms. and 31.7 cms. In the bottom left-hand corner of the slab are two small irregular circles, the right-hand one with diameters of 12.7 cms. and 15.2 cms., the left-hand one 15.2 cms. and 16.5 cms. Above these lies a pear-shaped figure 25.4 cms. by 20.3 cms., and contiguous with it is another irregular figure 22.9 cms. by 11.4 cms. in part concurrent with the barred circle. These two figures make an irregular 8 with a projection from the middle. The top outer edge of the 8 is continued by a curved line of indentations, 13 in number, which is terminated by a horizontal row of four indentations. At the top left-hand corner of the slab is an irregular circle with diameters of 25.5 cms. and 24.8 cms. To the right of this lies another irregular barred circle with diameters of 46 cms. and 28 cms., the right lobe containing two indentations, the left, one. A single indentation lies between these two figures. The width of the grooves throughout the design varies from 7.6 cms. to 2.5 cms., the depth is 2.5 cms., and all are abraded by erosion. At the toe of the slab may be seen part of a circle which has broken off, and below it lie several other fragments that have broken away.

THE OCCURRENCE OF THE FRESHWATER POLYZOAN, *PLUMATELLA REPENS* (VAN BENEDEN), IN TASMANIA.

By

V. V. HICKMAN, B.Sc., B.A., and E. O. G. SCOTT.

Plate V.

(Read 5th April, 1932.)

The present note records for the first time the occurrence of *Plumatella repens* in Tasmania. This widely distributed European species has already been found in Queensland, New South Wales, Victoria, South Australia, and New Zealand. It is not surprising, therefore, that its distribution should also extend to this State.

Our specimens were collected from a small creek which runs through the Punch Bowl Reserve, near Launceston, and we have met with it also in a creek running through Harland Rise, the estate of Mr. H. Dowling, near Evandale. The Polyzoon seems to flourish during the months October, November, and December. It is during this period that the creeks are running slowly and well stocked with algæ. The colonies of polypides are generally attached to the under-surface of stones and sunken logs, and a single colony may cover an area of 100 square centimetres.

The chitinous ectocyst is transparent when newly formed, but soon becomes brown and almost opaque, owing to foreign particles which adhere to its outer surface. The branching of the colony is characteristic of the species.

In January the creeks become almost stagnant, and the polypides die, leaving the brown ectocyst still attached to the surface on which the colony was growing. This somewhat disintegrated ectocyst generally contains a number of statoblasts.

The typical statoblast of *Plumatella* has the form of a more or less opaque ellipsoid germinative body, ringed with a semi-transparent annulus of air-cells, the float, which assists in dispersal; the whole structure exhibiting a rough resemblance to the samara of the common elm. As is well known, the statoblasts, even when derived from a single

polypide, manifest considerable diversity in size, colour, and details of structure, the variation being largely, but apparently not entirely, in accordance with the state of development.

The following records of dimensions, obtained by the measurement of ten examples, mounted in balsam, give some idea of the general variability in size:—

- (a) Total length: maximum,  $677\mu$ ; minimum,  $377\mu$ ; average,  $478.3\mu$
- (b) Total breadth: maximum,  $382\mu$ ; minimum,  $274\mu$ ; average,  $324.5\mu$ .
- (c) Length, excluding float: maximum,  $447\mu$ ; minimum,  $250\mu$ ; average,  $341.0\mu$ .
- (d) Breadth, excluding float: maximum,  $329\mu$ ; minimum,  $202\mu$ ; average,  $266.9\mu$ .

The ratio of total length to total breadth ranges, in these ten examples, from 1.33 to 1.78, and has an average value of 1.47.

The central germinative body is brown or red in colour. In statoblasts found in the living colony, it is generally more or less granular in structure, the granules often exhibiting a tendency towards segregation into irregular polygonal groupings, which, exceptionally, may become fairly regularly hexagonal. Occasionally, presumably when development is well advanced, there may be observed about half a dozen concentric elliptical rings, surrounding a dark central spot. The body is bounded, in examples taken from living polypides, by a well-defined, apparently structureless amber-coloured ring, having an average width of 6 or 8 microns. A layer of hexagonal cells, apparently continuous with the cells of the float, usually invests the germinative mass, either partly, forming a peripheral annulus, commonly from 2 to 5 cells wide, or, especially in fully mature examples, wholly.

The float, which has the form of a thin, more or less transparent ring of slightly elongated hexagonal air-cells, is typically elliptical, or somewhat panduriform, in outline. It may be colourless, slightly greenish, pale-yellow, or, in older statoblasts, golden. It is, in general, fairly symmetrically disposed round about the germinative mass, normally extending further beyond it along the major than across the minor axis. Occasionally the lateral portions of the float are not in evidence at all when the statoblast is



A Colony of *Plumatella repens* (van Beneden).





viewed from above or below, the whole structure then having the form of a central ellipsoidal mass, with a bluntly rounded wing projecting for a distance of about  $100\mu$  from either end. At times the periphery of the ring of air-cells exhibits a more or less pronounced rim, a single cell thick. In the so-called "sessile" statoblasts the float is absent. Two such floatless statoblasts were found to measure, when mounted, 433 by  $350\mu$ , and 447 by  $338\mu$ , respectively.

#### EXPLANATION OF PLATE.

A colony of *Plumatella repens* (Van Beneden), growing on underside of a stone from the Punch Bowl Creek, Launceston.

## A NEW PROTOZOAN PARASITE FROM A BDELLID MITE.

By

G. BOURNE,

Department of Biology, University of Western Australia.

One Text Figure.

The parasite here described was found occurring in one of four Bdellid (*Biscirus intermedius*) mites from Tasmania. The mite containing the parasite was kindly placed at my disposal by Mr. H. Womersley, A.L.S., F.E.S.

The parasite was present in the abdominal region of the mite, the exact position being shown in the figure. It was reniform, and was approximately one-eighth the size of the animal.

The general appearance was rather Sarcosporidian in nature, under low power being somewhat granular. Under higher powers no sign of spores could be observed, the granules appearing purely protoplasmic in nature.

Attempts were made to stain the parasite *in situ* with borax carmine. The protoplasm of the mite was, however, more chromophilic than that of the parasite, or there may have been a stain resistant wall around the parasite; in any case, it was quite obscured by the deeply staining mite cytoplasm.

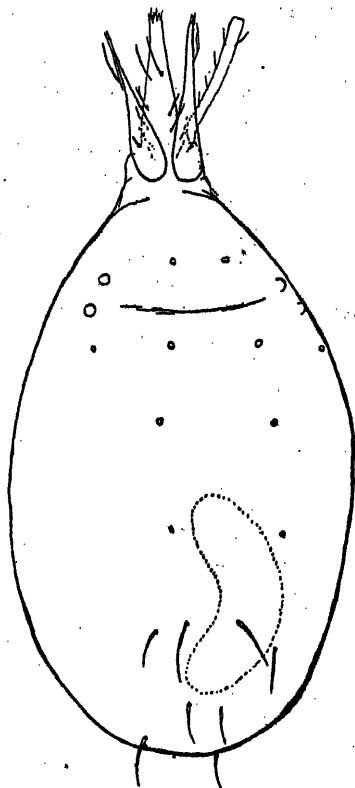
The abdomen of the mite was dissected off, and with the aid of a microscope and fine needles the parasite was removed from the abdomen.

Freed from the surrounding host tissues, the parasite was observed to be stained a light pink by the borax carmine, the granulations of the cytoplasm not indicating any chromophilic tendency, and even when the parasite was broken there was no indication of contained spores.

It was at first thought that this parasite may be an egg, but it is at least twice as large as any Bdellid egg known, and, in any case, the eggs of these mites are invariably

perfectly spherical, produced in greater numbers than one at a time, and covered with numerous clavate hairs. There was no signs of hairs on the parasite.

The possibility of the parasite being some object that the mite had ingested was also considered, but this was precluded by the fact that it was not within the alimentary canal, and appeared to be free within the body cavity.



Drawing by Mr. H. Womersley, A.L.S., F.E.S., of the mite *Biscirus intermedius* (Sig Thor), showing the parasite dotted in position in the abdominal portion of the mite. (Times 55.)

It is unlikely that it would be the egg of invading multicellular parasites such as Nematodes, since, for one of these to lay an egg this size it would need to be at least as large as the mite.

## SYSTEMATIC POSITION OF THE PARASITE.

The parasite described above does not appear to be represented in the literature, but is obviously Protozoan in nature, a member of the Sporozoa.

The only group into which this parasite could be made to fit is that known as the Haplosporidia, which Wenyon considers may be fungoid in nature. Wenyon states in connection with the Haplosporidia that "they are found in aquatic Invertebrates and Fish." Sig Thor has, however, found small bodies in mites on the Continent which he has referred to Haplosporidia; his parasites are, however, very different from that here described.

The parasite is undoubtedly different from any other recorded type, and would appear to be somewhat akin to the Sarcosporidia before they begin to divide up into spores and simply possess granular cytoplasm. The position in the host (free in the body cavity) would indicate some connection with the Haplosporidia. It is probable that at a later stage the parasite would divide up to form spores, and that the stage which has been described is very young. From the fact that only one mite in four from the same locality, and no other of some hundreds of Australian Bdellid mites examined by Mr. Womersley have show the presence of this parasite, and no other worker appears to have observed it, it is apparently quite rare.

In view of the lack of knowledge of the spores of this parasite, it is difficult to refer it to its exact systematic position, although I am placing it tentatively in the Haplosporidia. I feel, however, that it will eventually require a new order of the Sporozoa to receive it; this could not be done with the material so far examined, and until a more detailed knowledge of the various forms of the parasite during its life history is available.

## REFERENCES.

- THOR, SIG: "Skrifter om Svalbard og Ishavet, No. 27. Oslo, 1930.  
WENYON: "Protozoology," Vol. I. London, 1926.

## ACKNOWLEDGMENT.

I am greatly indebted to Mr. H. Womersley, A.L.S., F.E.S., for advice in connection with this paper and for kindly supplying me with the illustration.

## A NEW TASMANIAN TERRESTRIAL ORCHID.

By

W. H. NICHOLLS.

(Communicated by Clive Lord.)

Plate VI.

(Read 9th December, 1932.)

*Caladenia echidnachila*, n.sp.

*Planta terrestris, gracilis; habitu Cal. Patersonii*, R. Br.; *folium linearo-lanceolatum, hirsutum, canaliculatum; flores 1 vel 2, majesticali; lutei et rubri; ovarium densissime-hirsutum; perianthii-segmenta sub-aequalia, lineara et oblongo-lanceolata, filamentosa, glandulosa, patentia, pendula; caudæ 4-5 cm. longæ; sepalum-dorsale erectum, incurvum; labellum breviter unguiculatum, ovatum, apice filamentosum, glandulosum, obscure tri-lobatum; callis anguste-linearibus et robustiusculis, sex-seriatis, prope medio terminantibus; columna circiter 1.3 cm. longa, erecta, incurvata; anthera brevis.*

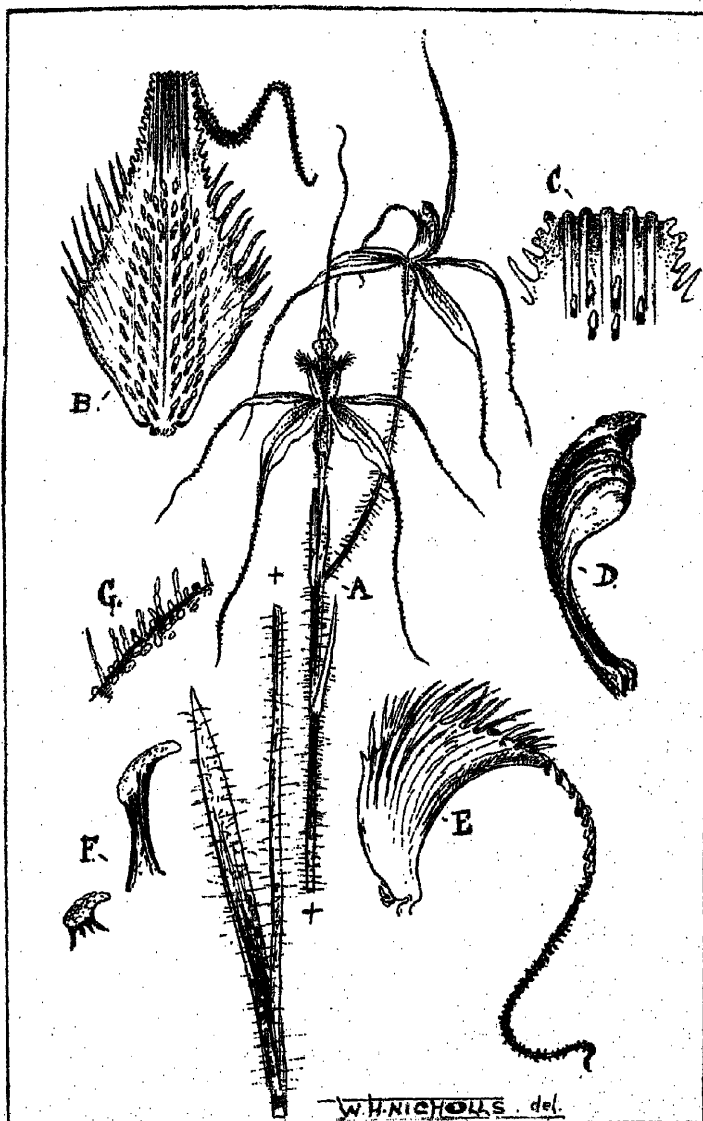
[A slender, moderately hairy species, with the habit of *Cal. Patersonii*, R. Br.; leaf hairy, linear-lanceolate, channelled; flowers 1-2; yellowish with crimson veinings and darker filamentous-glandular caudæ to the segments; caudæ about 4-5 cm. long; ovary covered with dense glandular hairs; lateral sepals and petals narrow-lanceolate, spreading, pendant; with three narrow longitudinal, central lines; sepals and petals about equal in length, petals narrower than the sepals; dorsal sepal erect, incurved; labellum erect, on a small movable claw, ovate-lanceolate, acuminate, yellowish with pale, diffused crimson veinings; tip wholly dark crimson, lower part of lamina erect, with entire margins, then deeply fringed; anterior margins serrulated; apex produced into a long, tapering filamentous-glandular process, fully twice as long as the broad portion of lamina (total length of labellum, 3.5-4 cm.); calli fleshy, slender, clavate, golf-stick type, in 6 rows, forward calli short and stout, not extending beyond the bend; five conspicuous longitudinal ridges continuing from between the rows of calli towards the tip; column erect, incurved about 1.3 cm. long, widely winged above; 2 yellow sessile glands at the base; anther with a short point.]

The above description is based on two specimens forwarded by Archdeacon Atkinson, and discovered by his sister, Miss H. M. Atkinson, of Lenah Valley, Hobart. The habitat is Lenah Valley. The labellum is unique within the genus *Caladenia*, R. Br.; and has been likened to the "long worm-like extensile tongue" of the "native porcupine" (*Echidna aculeata*).

This interesting species is closely related to *Cal. Patersonii*, R. Br., but differs from that well-known "spider" in all its variations, and also from all other closely related species, chiefly in having a long filamentous apex to the labellum. Flowering in October.

It is a remarkable addition to the Flora of Tasmania.

The type specimen is in the Tasmanian Museum, Hobart.



*Caladenia echidnachila*, n.sp.

- A. A typical plant.
- B. Labellum from above (spread out).
- C. Fore part of labellum-lamina, showing ridges.
- D. Column from side.
- E. Labellum from side. Note character of marginal fringe.
- F. Calli from the labellum-lamina.
- G. Glands from the perianth-segments. (Figures of details variously enlarged.)





# NOTE ON THE ORIGIN OF THE GREAT LAKE AND OTHER LAKES ON THE CENTRAL PLATEAU.

By

A. N. LEWIS, M.C., LL.D., M.H.A.

Plates VII.-XX.

## 1. INTRODUCTORY.

The Central Plateau of Tasmania is a pivotal feature of Tasmanian physiography and industrial enterprise, but has been rather neglected by geologists. The topography of the plateau has been well known since the earliest days of the pastoral industry, and several general accounts are available (see, e.g., the references at the end of this paper). Much of the plateau is still difficult of access, although the roads to the fishing resorts and engineering works have made considerable sections far more accessible than was the case thirty years ago. A current, though erroneous, opinion, that the surface of the plateau is covered with uniform dolerite, is not glaciated, and carries little interesting vegetation, has been largely responsible for a seeming lack of interest.

I feel that it will be many years before I am in a position to offer a complete geological map of the plateau, in view of the number of years that have elapsed since I first commenced this task, but I also feel that I should present these notes to amplify the recorded descriptions of this most important region, and to correct some errors which have worked confusion in general statements of Tasmanian geology.

## 2. THE CENTRAL PLATEAU.

The area under discussion is an accepted geographical feature bounded by lines connecting Cradle Mountain, Dry Bluff, Miller Bluff, Table Mountain, and Mount Olympus, with the Eldon Range, Mount Gell, the King William Range, and Black Bluff as outliers, an area of some 2000 square miles, averaging 3000 feet in elevation, and with marked escarpments to the lower lands below. The best

description is to be found in R. M. Johnston's "Geology of Tasmania" (Johnston, 1888), although the Denison Range should not be included. Further general description by me must be excluded for lack of space.

### 3. PREVIOUS ACCOUNTS AND OPINIONS.

General descriptions such as those contained in Breton's account of a trip from Cressy to the Great Lake (Breton, 1846), and in Geoffrey Smith's account of his trip from Bothwell to the Great Lake and thence to Lake St. Clair (Smith, 1910), are interesting, but throw no direct light on the geology of the area. Accounts published in Strzelecki's and R. M. Johnston's geologies (Strzelecki, 1845; and Johnston, 1888) are to such an extent based on discarded theories as to be now only of historical interest. Colonel Legge's work (Legge, 1902, 1903, and 1904) is of vital importance to the geographer, and its detail must be of value for all time as a basis for any work on the Great Lake; but, again, it is not directly a geological account. These facts limit the previous accounts of the geology of the region to a very small scope.

Most of the western edge of the plateau has been very fully described and mapped—the Cradle Mountain-Barn Bluff district by Dr. Benson (Benson, 1916); the Pelion district, immediately to the south, by Mr. McIntosh Reid (Reid, 1919); and the Lake St. Clair district by Mr. Clemes (Clemes, 1924). This leaves only the Du Cane Ranges untouched in that section. A corner of the eastern edge, round Lake Sorell, has been mapped by Mr. Nye (Nye, 1921). As to the remainder of the plateau, the great area of upland moors, lakes, and tiers, there is no detailed geological account, and I regret that I can contribute so little to remedy this deficiency.

In 1893 the late Mr. R. M. Johnston said: "I have, from long observation, arrived at the conclusion that the larger lakes on the higher levels of the greenstone plateau—such as Lake St. Clair, Lake Sorell, Lake Echo, Lake Arthur, and Great Lake, together with innumerable lakelets and lagoons on the upper levels—have been mainly determined by the original irregularities of the surface, produced partly by the anastomoses of successive flows of greenstones during their eruption, and partly by the unequal contraction due to lack of homogeneity of the cooling surfaces of the more massive horizontal flows of greenstone magma . . . ."









(Johnston, 1893). Such view depended on the idea that the dolerite (greenstone, diabase) was eruptive. This theory has long since been discarded, but Mr. Johnston's explanation of the origin of the large lakes has not been revised. Mr. Johnston, in the same paper, discounted the suggestion that these lakes may be of glacial origin. Speaking only of Lakes Sorell and Crescent, Mr. Nye said, in 1921: "These two lakes occupy depressions in the diabase formed by the denudation of the Trias-Jura sediments which once covered this part of the plateau." And, again: "Not the slightest evidence of any Quaternary glaciation is to be found, and it is concluded that this part of Tasmania escaped the glaciation of the above period, so common in the western part of the State" (Nye, 1921). About the same time Mr. Loftus Hills, then Government Geologist, stated to me that, in the course of an investigation of the site of the Great Lake dam at Miena, he could not find any trace of morainal deposits at the outlet of the lake. Colonel Legge recognised the effect of present-day ice on the Great Lake, but did not comment on the possibility of a glacial origin. In passing, I desire to call attention to some remarks on the general geology of the plateau made by the late Mr. Tom Stephens in 1899 (Stephens, 1899), which remarks are fully borne out, as far as they go, by my observations. Reference should also be made to the fact that since 1912 the Journals of Parliament (Tasmania) contain an annual report of the Hydro-Electric Department, and of the hydrometric survey conducted by that department for some years, with plans, some sketch-maps, and photos. These provide a history and description of the engineering operations of the department and some account of the Great Lake-Ouse area. No direct geological information is contained in these reports.

#### 4. GEOLOGY OF THE PLATEAU.

The Central Plateau consists of a base of Pre-Cambrian to lower Palaeozoic rocks, covered unconformably by Permian-Carboniferous and Triassic sediments, deposited in a manner which clearly shows the existence of an undulating topography at the commencement of the deposition and a gradually sinking sea-floor. The older rocks appear from the vicinity of Quamby Bluff, westward and southward to the vicinity of Mount Arrowsmith, but are not exposed under the more recent series on the east and south of the plateau. The whole sedimentary series was penetrated by dolerite at the close of the sedimentary phase (probably



middle Triassic), but the dolerite, as is usually the case, particularly invaded the upper coal measures and sandstone rocks of the Triassic period. I do not think that the dolerite can be regarded as one sill. Detailed mapping will probably show many irregular transgressive masses, with large horizontal sills intruding outwards in one or more directions. Many of the more spectacular escarpments, such as Table Mountain and Dry Bluff, represent the passage of fault-lines through such sills; and, to the westward, in the area in which lower-Palaeozoic and pre-Cambrian rocks are now seen at an elevation of 2000-4000 feet, the sill extensions appear to have been more pronounced.

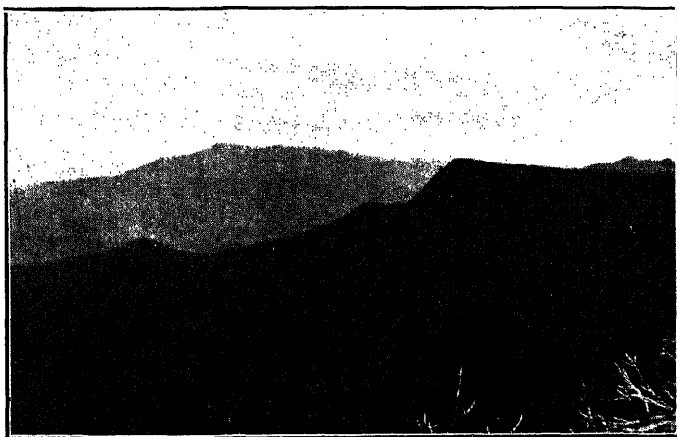
Dolerite, massive or as accumulations of talus, occupies the greater part of the surface of the plateau, but sedimentary rocks (Triassic sandstones and Permo-Carboniferous mudstone) appear on the boundary escarpment of the Western Tiers from an elevation of about 2800 feet downward, in most of the valleys draining the plateau and in many places on the plains of the higher elevations. Sedimentary and metamorphic rocks compose many of the prominences towards the north-west corner, even up to elevations of 4000 feet (see Plate XXXVI: "Coal Resources of Tasmania"; and Reid, 1919, Plate IV.). Much of the surface of the plateau, particularly on its southern slopes, is covered with olivine basalt lava-flows assigned to Tertiary age, and, in places, these overlie and protect Tertiary river conglomerates.

The whole mass of the plateau is marked with faults, traversing all rock series. No information is yet to hand as to the age of this faulting, or as to its relationship with the general uplift of the plateau. Efforts to trace the fault-line usually end at a spot where, apparently, one dolerite mass is faulted against another, and information as to general trend lines and other important data which will be provided by accurate mapping must await the completion of this task. There is little doubt in my mind that many of the minor features of the plateau, such as escarpments, tiers, and river valleys, are largely controlled by fault-lines. There appears to be a general tilting of the plateau mass from the north-west downward towards the south-east; but this is probably the results of a complicated series of step faults rather than a bodily tilting of the whole mass. Evidence exists that the uplift occurred earlier in the north-western area than in the south-eastern, and that the move-



[A. N. Lewis, Photo.

I. *Lake Sorell* from Interlaken. Mollie York's Night Cap  
in background.



[A. N. Lewis, Photo.

II. *The Western Tiers*, looking south-east from edge of tiers, north of  
Arthur Lakes, across gorge of Lake River.

Miller Bluff in background. Mount Patrick in background to right.



ment progressed south-easterly in large separate segments, becoming less marked during the progress.

Of the later sedimentary series, the upper marine mudstones are common round the base of the Western Tiers, in the valleys of the Mersey, Forth, and Ouse, and elsewhere round the south and east of the plateau. Lower coal measures have been reported as occurring at Bashan, and lower marine limestones high in the gorge of the Meander. Probably other occurrences will be found when the Western Tiers are mapped. Ross sandstones occur under the dolerite in almost every exposure of the bottom of the sills, and also on top of that rock in many places. Felspathic sandstones and shales occur in a few localities.

The geology of the plateau corresponds remarkably to that of adjoining areas, e.g., the Midlands or Bothwell-Hamilton district. The higher ridges are composed of dolerite, and stand out as long, narrow, and usually flat-topped lines of hills. In between lie rolling plains, covered largely with sedimentary rocks and basaltic lava-flows, and broken by lesser hillocks, often of dolerite. No one, when looking over any of the plains of the upper levels of the plateau, can help being struck most forcibly with the remarkable resemblance of that landscape to the Midlands plain. All the evidence at present to hand points to the conclusion that the Central Plateau is geologically a continuation of the Midlands, and that both these regions have been subject to identical physiographic influences during the greater part of the cycle in which the plains have been developed.

The more I consider the development of such features of Tasmanian physiography as the Central Plateau and other similar elevated blocks, the stronger I adhere to the general view as to their origin, already expressed (Lewis, 1926 and 1927), namely, that we see a post-dolerite (probably late Tertiary) peneplanation or semi-peneplanation, followed by the uplift of the plateau blocks to the position in which we know them. It is difficult to imagine the Western Tiers as anything other than a remarkable fault scarp. The present drainage can hardly have been responsible for the topography of the upper levels of the plateau. The gorges of the Forth, Mersey, Meander, Liffey, and Lake Rivers flowing north, and those of the Ouse and Derwent flowing south, are very recent features; but the elevated plateau mass shows features of a cycle previous to that initiated by the uplift. The degree of post-glacial river erosion

apparent in all these gorges is such as to preclude the possibility of the existence of the plateau features since the time of the dolerite intrusions. I regret that more attention has not been accorded to my explanation of Tasmanian physiography in the last six years, as, until this problem is settled, geographical work in general in this State must run the risk of being based on a fallacy.

The fuller examination which I have been able to give to the Central Plateau than has been possible to other workers, aided by experience gained elsewhere, enables me to say with certainty that the whole of the upper levels (above 2400 feet on the western side, 3000 feet on the eastern) were subject to ice-cap conditions during the Pleistocene ice age. This aspect will be more fully discussed later. The term "ice-cap" as used in this paper is to be taken as meaning an accumulation of ice on a mountain possessing a wide expanse of comparatively level surface. The features of the ice in this area show merely the characteristics of valley glaciers, with some modifications due to the plateau conditions, and the term is not used as indicating the features of a Continental ice-sheet.

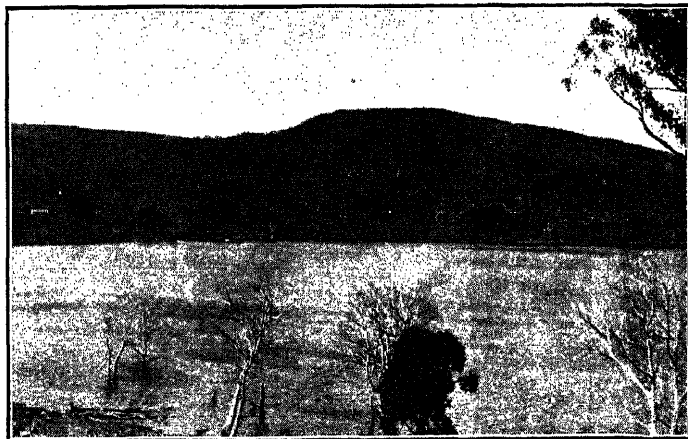
#### 5. LAKE SORELL AREA.

This district has been sufficiently described by Mr. Nye (Nye, 1921). The range forming the elevated edge of this plateau, and extending from Molly Yorke's Night Cap through Mount Franklin, and the Old Man's Head to Table Mountain, averages 3500 feet above sea-level, and was well above the snow line during the period of maximum intensity of the ice age. Ice appears to have moved from good névé collecting grounds in this high land. Glacially transported erratics are sparsely scattered over the flat and swampy course of the Mountain River, which enters the northern side of Lake Sorell (2800 feet). (This is just outside the area mapped by Mr. Nye.) Ice clearly moved southwards into the plain now occupied by the lake through one or more of these valleys. Suspicious, although vague, evidence exists of slight movements north-westward from Table Mountain towards Lake Crescent, and eastward from the Alma Pass tier towards Lake Sorell. Nowhere have I traced obvious morainal deposits except in the valley of the Mountain River, but it is quite possible the lakes now conceal the locality of the termination of the ice. Nevertheless, the area was subjected to Pleistocene glaciation to some extent.



[A. N. Lewis, Photo.]

III. *North Arthur Lake.* Mount Patrick in background. Morainal deposits in foreground.



[A. N. Lewis, Photo.]

IV. Rudimentary Cirque at head of the Little Lake—Great Lake.



## 6. ARTHUR LAKES AREA.

These lakes lie in a broad, flat plain at an elevation of 3090 feet, and separated from the Lake Sorell plain by Alma Tier (3500 feet). At the head of the plain stands Brady's Lookout (4497 feet), and high tiers surround the lakes, except for a small space to the north and a wider opening to the south. The Sandbanks Tier (3500 feet) separates this area from the Great Lake district to the west, and a second ridge runs southwards round the east and south-east of the area through Mount Patrick to Mount Penny (3792 feet). The plain feature extends southwards over St. Patrick's Plains, The Steppes, Lagoon of Islands, and Lake Leacock, and disappears without further elevation in the valley of the Shannon.

A considerable quantity of Ross sandstone occurs over the site of the southern Arthur Lake, in the valley of the Lake River, and westward under and round the southern end of Sandbanks Tier, to the western shore of the Great Lake. Basalt covers much of St. Patrick's Plain and the eastern slope of Barren Tier. On the north-eastern slopes of the lastmentioned feature, overlooking the Great Lake, there are outcrops of Tertiary river conglomerates. Ilmenite sands occur on the floor of Arthur Lakes.

It is probable that the whole of this area was covered by ice during the ice age, but I have not traced direct evidence south of a line between Mount Penny and the southern end of the south Arthur Lake. Northward of this line the evidence is plentiful. The ridges south of Brady's Lookout have been swept clear of loose boulders, and glacial erratics are common over the surface of the plain. Little Lake, to the north of Arthur Lakes, and only 100 feet higher in altitude, lies in terminal moraine country, and the shallow valley through which its overflow reaches Arthur Lake is strewn thickly with erratics of both dolerite and sandstone. Similar, although less plentiful, evidence exists in the area of the plain through which Tumbledown Creek flows, on the neck of land between the two Arthur Lakes, and in extensive fields bordering Sandbanks Tier on the south-east. It is probable that the Arthur Lakes are dammed by morainal material, although I cannot assert this with any degree of certainty. The more prominent ridges of the tiers and larger hills show the typical shattering effect of intense nivation due to protrusion from the ice as nunataks.



The ice appears to have accumulated on the slopes of the flanking ridges, and to have moved in a broad shallow sheet southwards and south-eastward over the area. In a few isolated places it moved northwards and fell over the edge of the plateau. I have not determined the maximum extension. It is possible that ice covered in one sheet the whole area southward to the Steppes, Lagoon of Islands, and the edge of the Shannon valley. If this eventually is proved to have been the case, the more obvious occurrence over the site of the Arthur Lakes would represent a subsequent phase. The area around Little Lake was certainly subjected either to a further phase or, more probably, a much later and more prolonged glaciation than the Arthur Lakes area. The evidence of these phases is very uncertain in this vicinity, and considerably more field work is necessary before a definite statement is possible.

The Lake River has eroded a tremendous gorge as it passes over the edge of the plateau. This has cut southward considerably in post-glacial times, and has removed much of the glaciated landscape just where the vital evidence of terminal moraines might have been expected. A depth of 200 feet has been eroded since the glaciation of the area immediately south of the Arthur Lakes. Incidentally, it may be pointed out that the Lake River has captured the drainage of the Arthur Lakes and Lake Leacock which originally flowed via the Lagoon of Islands and Blackman River to the Shannon. This capture appears to have occurred in post-glacial times, and is due to the considerably greater fall and, hence, cutting power of the Lake River as it passes over the edge of the tiers. There is also evidence of drainage from the south Arthur Lake to the Shannon in the vicinity of St. Patrick's Plains. This may be referable to an interglacial epoch prior to the formation of the lakes and the outlet via Lake Leacock.

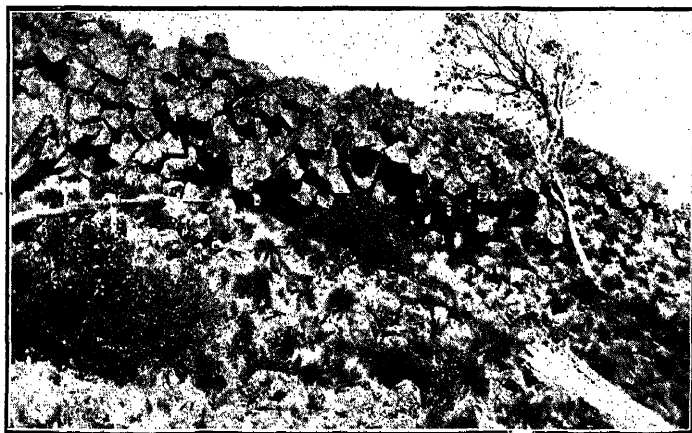
## 7. THE GREAT LAKE AREA.

This district lies to the west of the one previously described, and is separated from the Arthur Lakes plain by the Sandbanks Tier. It may be considered as a broad, flat valley which is mostly occupied by the Great Lake, 60 square miles in area, and, prior to the building of the Miena dam, averaging only 12 feet in depth, with very few places exceeding 20 feet (Legge, 1904). The plain is bounded on the east by the Sandbanks Tier, on the north by the



[A. N. Lewis, Photo.]

V. Glacial Erratics on shore of Shannon Lagoon, below Miena  
Dam—Great Lake.



[A. N. Lewis, Photo.]

VI. Basalt at "The Battery"—Great Lake.



raised edge of the plateau, Sandbanks Tier joining to the high country south of Mount Tabletop and Mount Projection, these features themselves being portion of the Dry Bluff mass. To the north-west the elevated country is continued as Bastion Bluff, and to the west Split Rock Range runs southerly for some 10 miles. To the south-west the Great Lake plain merges into the Ouse plain, and to the south it is bounded by Barren Tier, which has been cut through by the Shannon River. The surface of the lake is 3333 feet above sea-level, and the surrounding ridges average 4000 feet. The physiographic features of the lake have been very fully described (Legge, 1902, 1903, 1904). The rocks represented are dolerite over the northern portion, Ross sandstone merging into felspathic sandstone over the central portion of the southern lake, basalt covering the plain drained by the Ouse south of Liaweene, and appearing at the Beehives and the Battery on the shores of the Great Lake, with dolerite again at the Shannon outlet.

On the edge of the tiers, at an elevation of 4000 feet alongside the Deloraine-Great Lake road, is Pine Lake, a typical mountain tarn, lying in flat terminal moraine country. Small ice-flows, moving southward, coalesced over the site of the lake during the last phase of the ice age. A little further north the Liffey, a tributary of the Meander, has cut an awe-inspiring gorge, as it flows over the edge of the plateau. This has removed much of the glaciated surface between Dry Bluff and Mount Projection by headward erosion. A major fault appears to traverse the length of the Liffey Gorge, and this probably runs southward via Half-Moon Marsh, across the site of the Great Lake and down the Shannon Valley, thence in the direction of the present pipe-line to the Ouse Valley, in the vicinity of Waddamana. However, the statement that this is one fault is at present only assumption. The overflow from Pine Lake, known as Breton Rivulet, crosses flat moraine-covered country for a mile or so, then drops over an eroded rudimentary cirque wall for 300 feet to Half-Moon Marsh. This latter is a typical glacial valley, and ice passed thence over the present floor of the Great Lake. Traces of glaciation descending in a south-easterly direction to join the lastmentioned flow are to be seen in Mickey's Marsh, half-way between Pine Lake and the Little Lake.

The Little Lake and the north-western section of the Great Lake are bounded by a series of small, and not very distinct, cirques. More distinct evidence of glaciation occurs

at the north-eastern corner of the Great Lake, and it appears that the main ice-flow passed south-westward from the high country south of Dry Bluff, and coalesced with the other flows mentioned in the vicinity of the centre of the northern half of the Great Lake. A distinct bar separates the northern from the southern portion of the Great Lake (Legge, 1904). At the period of maximum glaciation, ice probably covered this, and coalesced with flows from the Ouse valley and from Sandbanks Tier, to be described next. At a later stage this northern flow probably terminated as a stationary sheet just north of Reynolds' Neck while ice from Sandbanks Tier still existed, also as a stationary sheet, over the southern portion of the lake.

The southern shore of the Great Lake presents features worthy of special mention. In the first place, most of the dissected plain extending from the Pine and Ouse Rivers to Sandbanks Tier, south of the Split Rock, is covered by a sheet of olivine basalt, through which dolerite hills rise as islands, e.g., Murderer's Hill. The basalt country is very easily distinguished by its mild topography. A ridge of this rock extends as a peninsula for 3 miles into the waters of the lake, and terminates in the Beehives. After being submerged opposite the mouth of the Shannon it appears again towards Todd's Corner, at the Battery, and thence extends southwards over the shoulder of Barren Tier. The valley southward of this ridge is drowned by the waters of the lake, and is known as Swan Bay to the west and Todd's Corner to the east. The next ridge to the south forms the shore of the lake, and consists of a line of dolerite kopjes. Further southward again is another more or less parallel valley, occupied in its lower portion by the Shannon Lagoon. Then Barren Tier terminates the Great Lake plain by a third parallel ridge. The features mentioned are primarily due to erosion, as is shown by the fact that the basalt ridge at the Beehives appears at the Battery as a continuation of the dolerite ridge, with which it makes one physiographical feature in the latter locality.

The Shannon cuts through the dolerite ridge at the site of the Miena dam, the keystone of Tasmania's industrial activity. When the foundations for this structure were being excavated the dolerite was found to be seamed with wide bands of weathered rock, which isolated seemingly solid surface outcrops as large floating boulders. This was more marked on the banks than in the bed of the Shannon, which appears to have removed the weathered material. Dr.



[A. N. Lewis, Photo.]

VII. Edge of Dolerite Sill. *Mt. Projection, Western Tiers*, from  
Deloraine-Great Lake road.



[A. N. Lewis, Photo.]

VIII. Moraine at *Pine Lake*, north of Great Lake.



Loftus Hills informed me after his inspection that the appearance was that of dolerite weathered *in situ*, and no suggestion that the bar was a glacial moraine could be found.

However, the valley south of the dam shows unmistakable evidence of glaciation. Erratics cover it sparsely from the Sandbanks Tier, across Todd's Corner, right to the Shannon Lagoon, and a few may be found on the west shore of the latter and in the valley leading to it from the south-west. At some stage ice passed down the Shannon, at least to the intake of the canal leading to the Shannon power-house, and probably further.

My explanation of the southern shore of the Great Lake is this. During the maximum extension of the ice age a large shallow ice-sheet covered the whole valley, and met the ice-sheet in the Arthur Lakes valley. Later, for a long period during the recession of this phase, smaller ice-sheets covered (1) the southern Great Lake to a depth of about 50 feet above the present water-level, deriving their source from Sandbanks Tier, the Ouse, and south of Murderer's Hill (this banked up against the northern slope of the dolerite ridge at approximately the present shore line of the lake); (2) immediately to the south a smaller ice-sheet, deriving its source from Sandbanks Tier and Barrier Tier, banking up against the latter. The Shannon gorge between the Lagoon and the Shannon power-house is, in its present configuration, definitely lower and wider than when the ice-sheets covered the area stated, although no evidence is at present forthcoming as to whether it is post-glacial entirely.

The dolerite bar and line of kopjes that now limit the southern shore of the Great Lake were eroded as a long razor-backed nunatak between these ice-sheets. It probably only protruded 50 feet at its eastern half from the ice, although the top of the ice over the Shannon Lagoon appears to have been some 50 feet lower than that over the Great Lake. It is possible that the Great Lake once drained to the Lagoon via Todd's Corner, and that the Shannon outlet at Miena was more recently eroded.

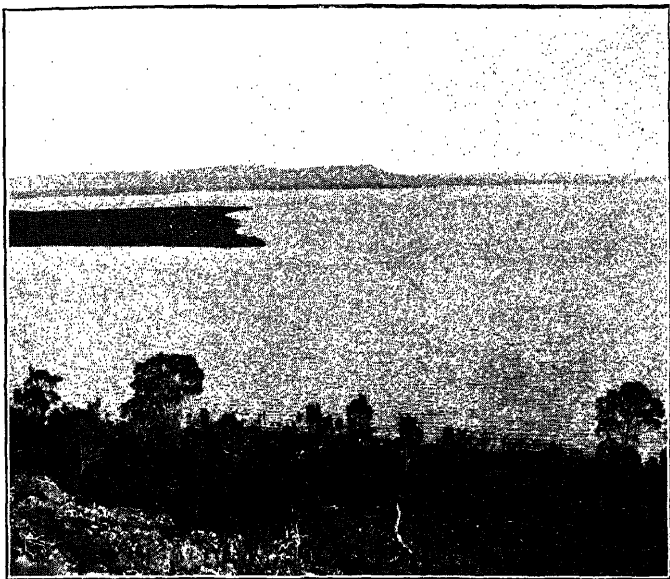
#### 8. THE NINETEEN LAGOONS - OUSE - PINE RIVER AREA.

The country between Mount Ironstone on the north-west, the Great Lake on the east, and the Pine River on the south-west, may be considered as the next geographical area, although no definite western boundary can be fixed. This is a bare, desolate moorland of rocky ridges, lagoons,



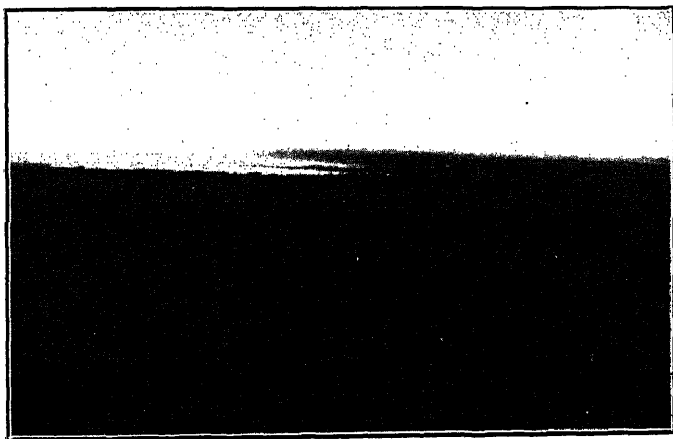
and swamps, difficult of access, and snow-covered during most of the year. To the north the edge of the Western Tiers rises in a long ridge (Bastian Bluff, 4400 feet, and Mount Ironstone, 4700 feet). Thence the land drops rapidly in talus-covered terraces to about 3700 feet, and then in a gently sloping plain for 20 miles, with a general south-easterly drainage to the gorges of the Ouse and Pine on the southern edge of the plateau. Near the middle of the plain a considerable nunatak ridge, the Little Split Rock, stands over Lake Augusta. South of this feature the valleys of the rivers mentioned and their many tributaries are more marked, and are separated by typically nunatak ridges of shattered dolerite, running generally south-east.

The whole of this area is intensely glaciated at least as far south as a line from Swan Bay to Lake Fergus, and I think, although the evidence is very slight, that ice at its maximum extension descended to the Skittleball Plains at least. At this period it probably coalesced with the ice of the Great Lake area across the plain between the Split Rock and Barren Tier. Much of the southern slopes of this area are covered by basalt, and consideration must be given to the different way in which this rock and the islands of dolerite protruding through it have been affected by weathering. It is easy, at first sight, to picture the topography of the basalt as due to ice, and that of the dolerite ridges as due to frost, action on the rock protruding through the ice-sheets, but the close association of rock type with topographical forms gives a warning that these differences may be due to normal weathering alone. For this reason, if it were not for the conclusive evidence of surrounding districts, I would hesitate to say that these basalt plains had been affected by ice. However, from the fact that ice did cover surrounding localities, and that basalt flows occurring on lower levels—for example, at Bashan—do not exhibit the appearance of an ice-cap topography, it is probable the plains between the Great Lake and the Skittleballs were covered by ice. Possibly the level, smoothed-out topography was due originally to pre-glacial erosion of the softer rock, and this induced an accumulation of ice during the ice age over the basalt, while the dolerite protruded as nunataks and ridges too steep for the snow to lie on. The ridge between Swan Bay and the Ouse, and that between the Ouse and the Little Pine Rivers, overlooking the Skittleballs, certainly show many small and rudimentary cirque features, and Lake Fergus is definitely of glacial origin. It is very probable that ice at some time



[J. W. Beattie, Photo.

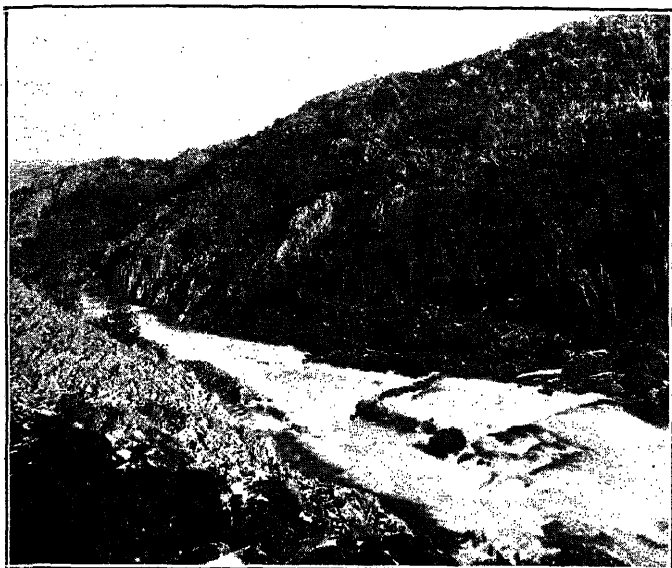
IX. *The Great Lake*, looking north from Miens, over Swan Bay and  
Beehives, to Split Rock.



[A. N. Lewis, Photo.

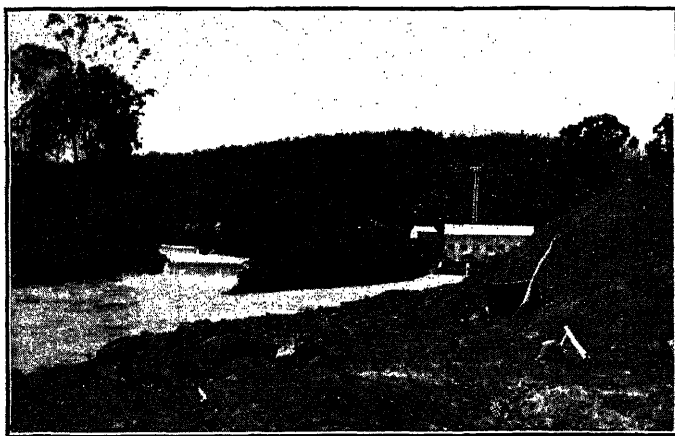
X. Most southerly of the Nineteen Lagoons, showing moraine dam.





[J. W. Beattie, Photo.

XI. Gorge of *River Ouse* at Liaweene, showing extent of post-glacial erosion.



[A. N. Lewis, Photo.

XII. Gorge of *Shannon River* through Barren Tier.

Shannon power-house in foreground. Drop of pipe-line (290 ft.) shows depth to which Shannon has cut in under 5 miles.



passed over the site of the Ouse bridge on the "Missing-link" track, and thence debouched on to the Skittleballs. Here, the post-glacial erosion appears to have been comparatively slight—not 50 feet in depth.

A little further north the effect of ice movement is more apparent. Here the sheet was divided for long distances by low parallel dolerite ridges, and some morainal deposits are apparent. A clear one exists in the valley of the Armytage Rivulet, due west of the Ouse bridge at Lia-weene. Thence northward to the Nineteen Lagoon area the country is certainly, although indistinctly, a huge terminal moraine area, and Lake Augusta, with its surrounding lagoons and swamps, is the result of the indeterminate drainage typical of such topography.

This glaciation becomes more and more obvious as you proceed northward. On the flanks of Mount Ironstone are many mountain tarns, such as Lake Meander, Lake Ironstone, Lake Lucy Long, and others. These are impounded behind typical valley glacial moraines. Moreover, they represent a later phase distinct from and covering the morainal deposits of the Nineteen Lagoon country. Opportunity has not occurred for me to investigate in sufficient detail the evidences of superimposition of actual moraines, but Dr. Loftus Hills has informed me of the existence of strong evidence of a definite inter-glacial epoch between moraines in the vicinity of the head waters of the Fisher River, and this locality should be productive of most important results when time can be found to explore the moraines in the necessary detail.

#### 9. LAKE ECHO AREA.

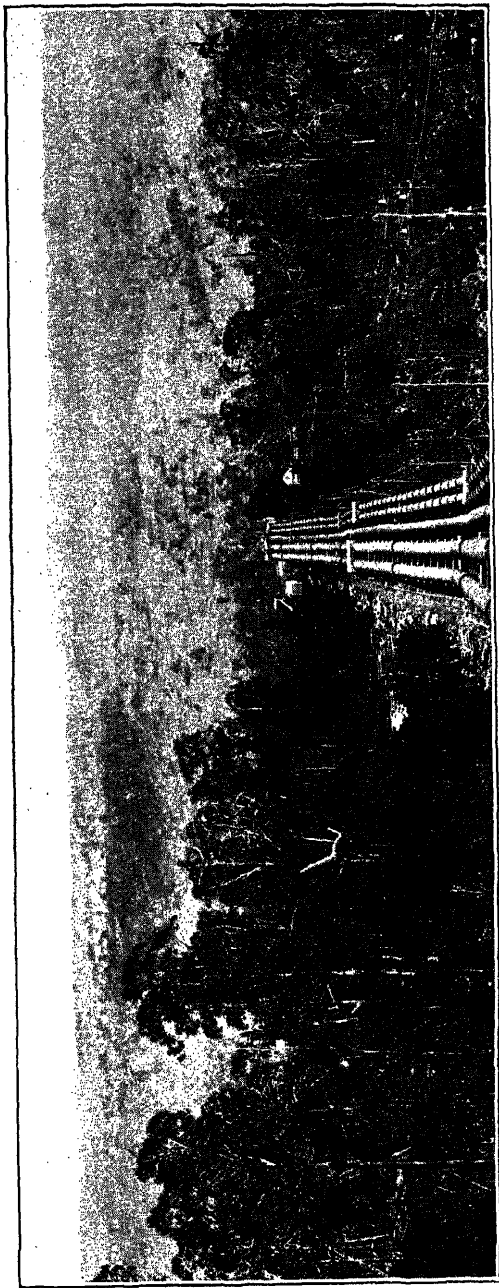
Lake Echo presents one of those difficult contradictions which, nevertheless, afford the clue to the whole problem. It lies well south of what might otherwise be considered the glaciated area, and is entirely cut off from the Great Lake and Ouse valley glaciations by river-eroded valleys. Its height (2717 feet) is somewhat less than that of the lowest locality in which glaciated topography can be identified with certainty in the northern areas. Nevertheless its origin must be identical with that of the other large lakes of the plateau. In fact, its basin is glaciated, and the surrounding valleys have been eroded subsequently. It appears, therefore, to represent a residual portion of the plateau as it existed at the time of the maximum extension of the ice-sheet.

The lake is enclosed in a circle of hills, rising to about 3500 feet to the north-west and 3000 to the south. It is also a shallow sheet, 20 feet depth being exceptional. North of the lake are considerable plains which appear to be portion of the same feature, now drained by tributaries of the Ouse, the valley of which has cut into them. Ice moved southward across this plain, over a low saddle, and into the north-east corner of the lake. Smaller flows moved south-eastward from the high ridges known as The Tops, lying between the lake and the Nive valley. These coalesced over the present site of the lake. The lake is at present dammed by a dolerite bar, through which the Dee is cutting. To the north-east of this, and extending to the basalt flows at Bashan, is an outcrop of sandstone. Ice seems to have passed across the present mouth of the Dee, and the dolerite here is either shattered by nivation or lightly covered by moraine, probably the latter. The valley of the Dee near the lake is covered by luxuriant vegetation of typically western flora, and this effectually obscures the evidence of morainal deposits. Post-glacial erosion does not appear to have reached the lake-level.

In this vicinity, and between here and Lake St. Clair, there are numerous valleys that have the appearance of more or less drained lakes—for example, Victoria Valley and Bashan Plains. Mike Howe's Marsh, in the valley of the Blackman River, east of Lake Sorell, is another example of this feature, and the Lagoon of Islands and Lake Crescent afford examples of the connecting links between these marshes and the shallow lakes. I have not yet discovered, however, any trace of glacial action south or east of Lake Echo, or lower than 2700 feet west of the Nive River, and these features are probably due to recent earth movements, with or without the interposition of the effects of ice.

#### 10. THE NINETY-NINE LAGOONS AREA.

Westward of the Pine River catchment, and stretching thence to the dissected western edge of the plateau, is a district well named the Ninety-nine Lagoons, although probably ten times that number of lakelets exist. Here the acreage covered by water may exceed that which is dry. The head waters of the Mersey and Forth, and their many tributaries flowing north, have cut deeply into the original plateau surface, and the Nive and Clarence, flowing south, have also eroded considerable areas, although not nearly



[J. W. Benthie, Photo.

XIII. Gorge of Ouse at Waddamana.

Power-station is on bed of river, 1200 feet below spot where pipes disappear. Uncovered plateau covered by basalt lava flows, and either glaciated or slightly affected by near proximity of glacial conditions, in background.

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XIV. *Lake Echo*, looking south.

[A. N. Lewis, Photo.]



XV. Glaciated Valley immediately north of Lake Echo.

[A. N. Lewis, Photo.]



to the extent of the northern rivers. The district is very flat, and to the north entirely covered by terminal moraine deposits, amongst which the lakelets lie. To the south the country is similar, but is traversed by long, low, parallel nunatakal ridges of shattered dolerite. A few outstanding mountains protrude, such as Culmar Bluff and the China Wall. These show typical nunatak features. I have not investigated this area in detail, but it appears that the ice responsible for the topography moved south-eastward from névé fields in the Barn Bluff, Pelion, and Du Cane Ranges, and is referable to the last phase of the ice age.

The Mersey, Forth, Nive, and Clarence have eroded much of the glaciated country, and the present features of these valleys are certainly post-glacial. They have not, however, entirely removed the glaciated plateau at their head. Both the Forth and the Mersey are working down fault-lines or zones. There appears to be a distinct break in the geology of the plateau from a general line through the Forth valley, and continued southward. Mr. McIntosh Reid's mapping indicates that westward of this line the elevation has been more considerable and, it seems to me, from the amount of erosion, earlier. Sedimentary rocks, pre-Cambrian schists, Permo-Carboniferous series, and Ross sandstones, &c., are to be found at 4000 feet, and are far more common than is the case further east. The dolerite appears as an elevated and thoroughly dissected sill.

#### 11. THE WESTERN RANGES.

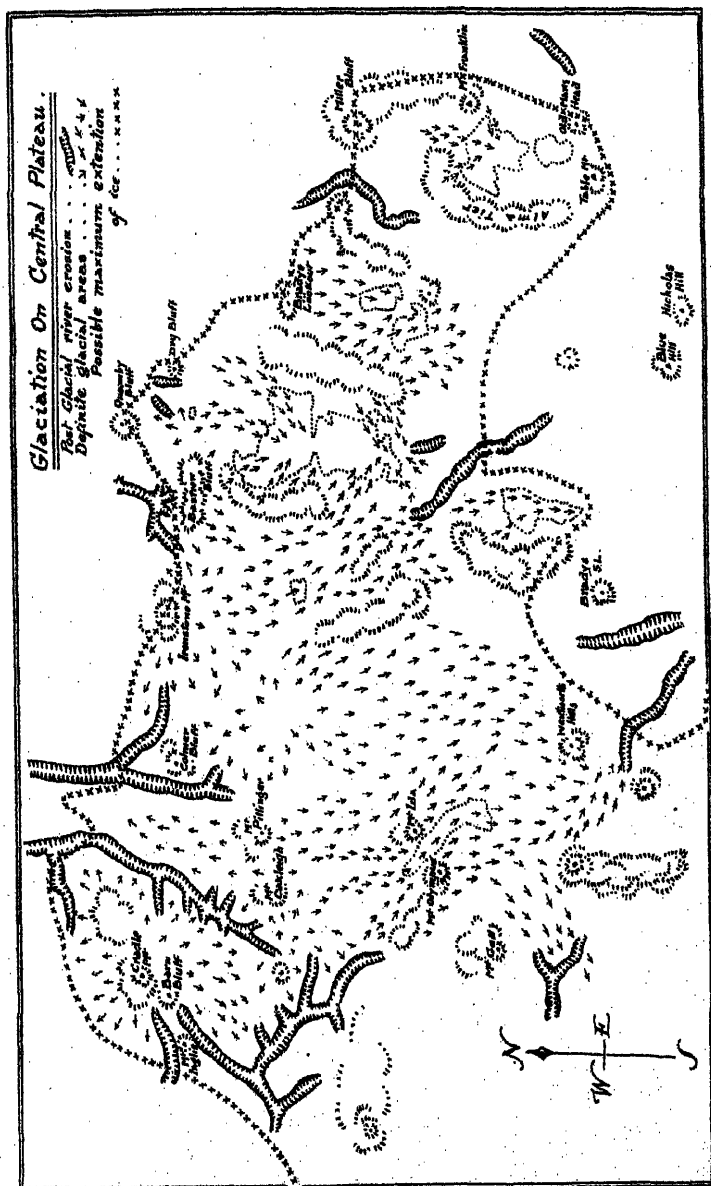
These have been fully described, as before mentioned, and I have no further data regarding this portion of the plateau. I merely desire to point out that these ranges must be considered as part of the Central Plateau. Their physiography has been determined by similar influences, although here these influences have been more intense. The main valley features and the dissection of the plateau were largely completed in pre-glacial times. Thus the ice was accorded fields on which to accumulate and valleys through which typical valley glaciers could move. These features, and their absence further east, are sufficient to account for the difference in the glacial forms now apparent. Also, the precipitation was considerably greater on the west of the plateau, and thus the ice was enabled to reach lower levels. Ice certainly descended to 2300 feet at Lake St. Clair, and perhaps it reached as low as 2000 feet. The country in

the vicinity of the Clarence Lagoons, and that crossed by the West Coast-road in the Clarence Valley and westward to the Derwent, shows evidence of glaciation during an early phase. The Derwent has eroded its valley to within 10 miles of Lake St. Clair very considerably since glacial times, and many possible traces of the lower limits of ice movements have been removed.

## 12. PLEISTOCENE GLACIATION ON THE CENTRAL PLATEAU.

To summarise the conclusions forced by the field evidence noted above, it is sufficient to say that the plateau surface, as existing in Pleistocene times, was subject to intense glaciation in its north-western quarter, and thence the ice-sheet became thinner and finally broken into small occurrences. The whole plateau above 2800 feet was within the permanent snow-line during the most intense epoch. Except towards the west, the ice took the form of a fairly stationary ice-sheet, and the typical features of valley glaciation could only develop in a few localities. In consequence of the flat topography and the hard dolerite, little erosion was effected, and, from the same cause, morainal deposits are few. The erosion forms are mostly those of a typical ice-sheet. Post-glacial erosion in the river valleys has removed the traces of valley glaciation if such ever occurred. On the higher levels the ice-cap eroded considerable and frequent hollows by nivation when stationary during the recession period. There is distinct evidence of two phases and indications of a third and more extensive phase. The last phase appears to be superimposed on the earlier one, and the terrain presents great possibilities for the further study of this vital problem when the opportunity presents itself.

It must be borne in mind that the present-day conditions over the plateau are severe. During the winter of 1920-21, when the Great Lake construction works were in full swing, football matches were played on the ice of the lake. The winter snowfalls of the present time are sufficient to account for the treelessness of the higher plains, and ice in modern times has piled up shingle terraces round the lakes (Legge, 1902). Conditions similar to these must have existed at considerably lower elevations during the ice age. This and the ice-cap conditions during the maximum phase of the ice age, and the extent of post-glacial erosion, make it very difficult to say with certainty what was the limit of the ice-cap of the plateau. I have no hesitation, how-





ever, in saying that the country north of a line from Mount Charles to Table Mountain was affected, during the Pleistocene, if not by permanent ice, certainly by heavy winter snowfalls.

The ice-cap was never very thick; perhaps 100 feet was its maximum in the eastern half of the plateau. It covered pre-glacial plains, and all the then existing hills and prominences protruded as nunataks of bare rock. Most of this rock was dolerite, which is seamed with cooling cracks. The intense frost action, and the effect of heating during the day and freezing during the night, shattered this exposed rock, and gave us the typical hill features of this area, namely, a general appearance of vast accumulations of loose boulders.

The remarkably clear glacial topography made easily accessible by the West Coast-road clearly shows that, during the maximum phase of the Pleistocene ice age, the whole of the country from the Great Lake to the sea was covered by ice, except where mountains protruded. Evidence at present to hand points to a coalescence of a multitude of mountain glaciers into a more or less stationary ice-mass completely filling the valley and plain areas. The apparent gaps in this sheet in many places, as in the lower valleys of the King and Gordon and Derwent Rivers, are due to post-glacial erosion. This has effected a modification of the physiography of Western Tasmania to an extent not hitherto appreciated, and points to considerable uplift and rejuvenation by the river systems between the maximum phase and the most recent mountain tarn phase of the ice epoch which has been responsible for the more apparent moraines.

### 13. POST-GLACIAL RIVER EROSION.

The degree to which the rivers draining the plateau have cut into the glaciated surface of the original uplift has surprised me. This has not occurred materially in regard to the most recent morainal deposits, but the evidences of the earlier, and most extensive, glaciation have been largely removed. This forces the inquiry, whether the glaciated area of many of our other plateaux has not been greatly underestimated, and whether we have not been missing the identification of the lower limits of the Pleistocene ice-sheets by reason of subsequent erosion. This, in its turn, emphasises the importance of fuller investigation of glaciation at lower levels as occurring on the West Coast.

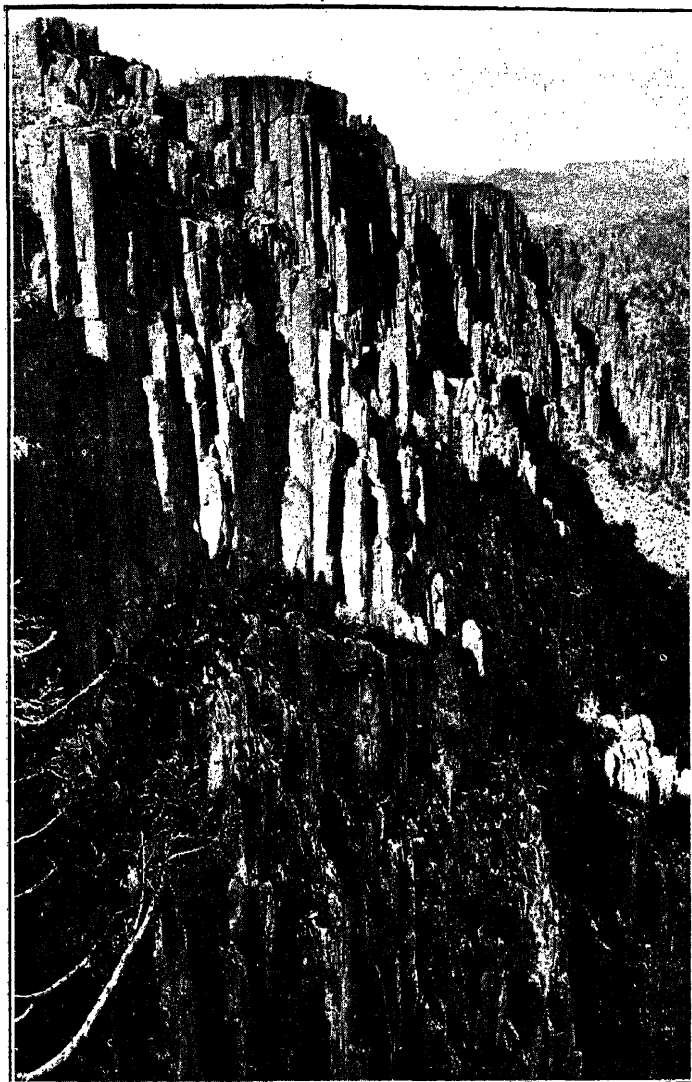


Commencing with the Ouse Valley, we see, at Waddamana, a gorge 1200 feet deep cut in the original plateau surface, which has also been thoroughly dissected by small tributary valleys of the Ouse. The remnant of the plateau above these valleys shows evidence of having been affected either by an ice-sheet or by severe snow conditions approaching those of permanent ice. Such topography crosses the Shannon and Lake Echo depressions, and the Ouse has eroded either its whole gorge, or substantially so, since the period of the maximum extension of the ice. This river has, by headward erosion, cut right into the moraine-covered plateau surface as far north as Lake Augusta. Opposite Swan Bay it has cut about 200 feet into the plateau since the maximum phase of the glaciation, and this is true for some 5 miles northward to the gorge north of the Ouse Canal at Liaweene.

The latter phases of the glaciation occupied this valley to about a mile north of Liaweene and further south in the Pine River and tributaries of the Ouse. The Ouse itself has cut about 50 feet into its valley as shaped by this last phase, but, owing to control by dolerite bars, much of the glacial topography in the upper portion remains.

The Shannon from the power-house to the Lagoon shows a smaller, but similar, gorge cut, or very considerably deepened, since the ice receded from the Greack Lake. This has cut at least 200 feet in dolerite in post-glacial times. The Dee and Nive have also cut considerable, although lesser, gorges in the glaciated surface of the plateau. It is apparent that the ice has considerably interfered with the normal sequence of river erosion. I cannot at present throw any light on the pre-glacial drainage. It is possible that, at some stage, the Great Lake drained into the Ouse, and thence, via the Skittleballs, into the Nive; but this is uncertain. The Shannon to a lesser extent, and the Ouse to a greater extent, have been active, in recent times, in capturing drainage from surrounding streams. The gorges of these rivers are of very recent extension into the plateau, and the Ouse has certainly captured much of the drainage of the Nive, and may shortly behead the Little Pine River, &c., at the Skittleballs.

A factor that is apparent in the upper portion of the Ouse, and which I have observed elsewhere, is that a stream will frequently erode round the side of an ice-filled valley, and a large glacier in the main valley will protect the



XVI. Edge of Dolerite Sill—Valley of Fisher River. [Spurling, Photo.  
Showing glaciated plateau above and post-glacial erosion of Mersey  
drainage system.

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the same time, the fact that the same person can be both a subject and an object of a relation, and that the same relation can be both a subject and an object of a relation, is a fact which is not captured by the traditional logic. This is because the traditional logic is based on the assumption that the subject and the object of a relation are distinct entities, and that the relation itself is a distinct entity. However, in the modern logic, the subject and the object of a relation are not necessarily distinct entities, and the relation itself is not necessarily a distinct entity. This is why the modern logic is able to capture the fact that the same person can be both a subject and an object of a relation, and that the same relation can be both a subject and an object of a relation.

Another important feature of the modern logic is its ability to handle the concept of self-reference. In the traditional logic, self-reference is considered to be a logical error, because it leads to a contradiction. However, in the modern logic, self-reference is not considered to be a logical error, because it does not lead to a contradiction. This is because the modern logic is able to handle the concept of self-reference by using the concept of a self-referential relation. A self-referential relation is a relation in which the subject and the object of the relation are the same entity. For example, the relation "is a" is a self-referential relation, because the subject and the object of the relation are the same entity. This is why the modern logic is able to handle the concept of self-reference without leading to a contradiction.

Finally, another important feature of the modern logic is its ability to handle the concept of infinity. In the traditional logic, infinity is considered to be a logical error, because it leads to a contradiction. However, in the modern logic, infinity is not considered to be a logical error, because it does not lead to a contradiction. This is because the modern logic is able to handle the concept of infinity by using the concept of a self-referential relation. A self-referential relation is a relation in which the subject and the object of the relation are the same entity. For example, the relation "is a" is a self-referential relation, because the subject and the object of the relation are the same entity. This is why the modern logic is able to handle the concept of infinity without leading to a contradiction.



[J. C. Breadon, Photo.

XVII. *Lakes Sandy Beach and McKenzie, under Mount Ironstone.*  
Note moraine in foreground, and also separating lakes.



[Spurling, Photo.

XVIII. *Mount Ironstone and glacial lakes in vicinity.*



terrain from erosion when a stream in a smaller adjacent valley is wearing down a bed below that of the ice-filled principal valley. After the disappearance of the ice these streams capture the drainage of the main valleys. It is, therefore, frequently found that the main drainage course of to-day was not the main valley in pre-glacial times nor the site of the largest glacier.

The northward flowing rivers, Forth, Mersey, Meander, Liffey, and Lake, have cut far deeper and more spectacular gorges, having reached soft sedimentary rocks below the dolerite (as is also the case with the Ouse). Their shorter and steeper slopes have enabled them to do this. But, at the same time, as they are cutting into the highest portion of the plateau, they have interfered less with the glaciated surface. In spite of this, river erosion has proceeded in all these cases to a very considerable extent since glacial times, perhaps to the depth of 2000 feet since the time of the maximum extension of the ice. All these questions of erosion are very uncertain, as evidences of valley glaciers in the gorges mentioned have been entirely removed.

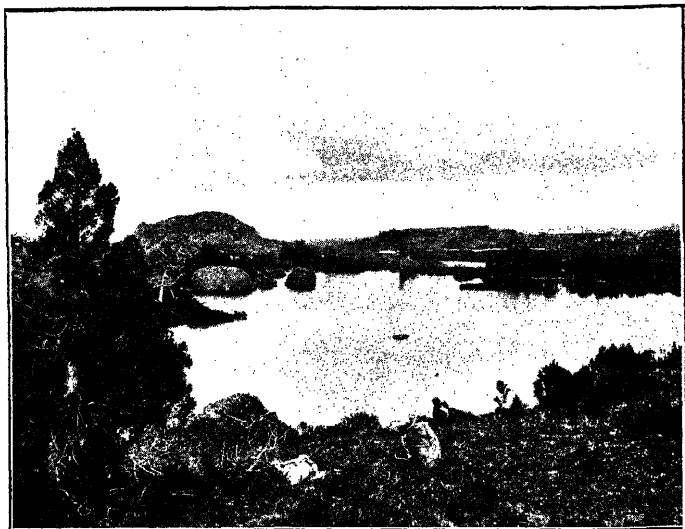
#### 14. OLDER PENEPLAIN OF THE DERWENT VALLEY.

Mr. Clemes has drawn attention to the existence of a lower plateau extending from Lake St. Clair to Lake Echo at an elevation of some 2500 feet (Clemes, 1924). This is so, but it extends far beyond the eastern boundary assigned by Mr. Clemes, and may be regarded as the same feature as the Oatlands spur of the plateau described by Mr. Nye (Nye, 1921). From Hamilton northward to the Steppes, north-westward to Lake St. Clair, north-eastward and eastward to Oatlands, Tunnack, and Colebrook, there is evidence of a dissected peneplain. This exists now as mere flat-topped residuals between wide valleys, and appears to have been uplifted in a series of step-faults to the upper levels of the Central Plateau. It corresponds with the Midlands in general, but is much more deeply cut by the river valleys. The general trend lines of the main uplift on the southern boundary of the plateau are not as clear as on the other sides, and the possibility of a partial subsidence, although not to the original level, must not be ignored. In fact, the uplift of the Central Plateau appears to have occurred by segments at different stages and to different heights, thus further complicating the deciphering of the physiographical influences.

15. ORIGIN OF THE GREAT LAKE AND OTHER LAKES  
ON THE CENTRAL PLATEAU.

As has been sufficiently indicated, the origin of all the lakes, except the Great Lake, Lake Echo, Arthur Lakes, Lake Sorell, and Lake Crescent, is definitely due to glacial action, and they in nowise differ from the mountain lakes and tarns of the western ranges. The only doubt exists as to the large lakes above named. It is certainly a difficult problem, and the evidence is not very obvious. The theory that they are due to original hollows in the dolerite must be discarded in view of the time that has elapsed since this rock first appeared, and the theory that they are due to unequal erosion of overlying sandstone is not sufficient to account for all the physiographic features surrounding these lakes. If there were no possibility of ice action, of course, another explanation would have to be sought, and previous opinions proceeded on this assumption. I have presented, I hope, enough evidence to show that the whole area was subject to ice action to a greater or less extent, and therefore the obvious cause was actually in operation.

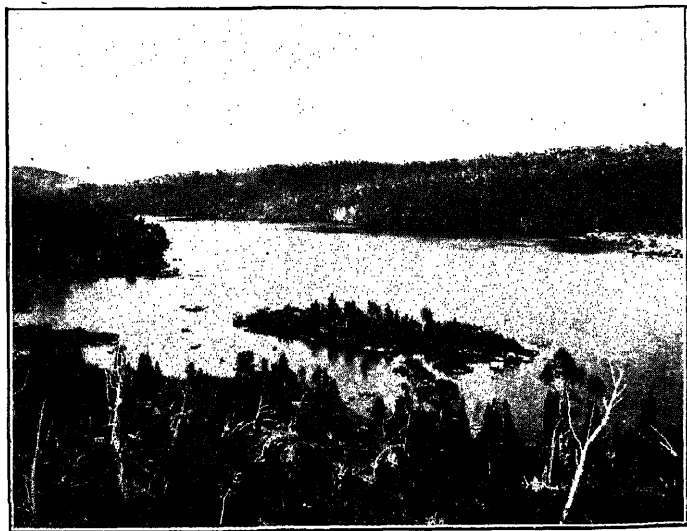
The lake basins in question have certain features in common. All except Lake Echo appear as two sheets, connected to a greater or less extent. In every case sandstone and basalt occur towards the overflow side, while the upper sides are shallow cirque-like depressions in the dolerite. These factors are common elsewhere, and therefore may be mere coincidents. The lakes are all extremely shallow for their area. This must be largely due to post-glacial deposition, particularly of diatomaceous mud, but the original flatness of the plains in which they lie is obvious. More important is the factor that in every case there occurs a considerable hill or tier on the outlet side, and the lakes lie over the site of the coalescence of two or more ice-flows, of which one or more moved to some extent against the general direction of the movement of the major flows. None of these lakes is dammed by a moraine, although morainal deposits occur to some degree near the outlet of all except Lakes Sorell and Crescent. It is clear, from evidence in the Midlands, that, although a river cannot erode a lake basin in the normal course of erosion, where a small creek suffering from floods cuts from a sandstone area through a bar of dolerite, it sometimes erodes the sandstone behind the bar to form a swamp which will flood into a lake. Add an invasion of ice to such an area, and the swamp could be



[Spurling, Photo.]

XIX. Ouse-Mersey Watershed.

Lake in foreground drains north, lake in background drains south.  
Note ice-cap topography.



[Spurling, Photo.]

XX. Glacial Topography at head of Nive River, in the Ninety-nine  
Lagoon Country.





deepened sufficiently to form a basin such as is now occupied by the large lakes of the plateau. It is not absolutely clear, however, that such a simple explanation, which is a possibility, is actually the whole story of the development of these lakes.

In my opinion, these large lakes occupy hollows which represent the final sites of small ice-sheets, the last remnants of larger sheets which imparted the typical ice-cap topography to the plains in which the lakes lie. During the recession period the ice became confined to certain localities, and here eroded slight depressions by nivation.

At the same time, the whole of Tasmania is rising at the present time, and this has continued since Pleistocene times, allowing for the more rapid rise of the sea-level during a comparatively short space of time. The valleys of all the streams show slight recent uplift, and this is particularly plain in the valleys of the Dee and Nive. It is quite possible that this gentle uplift has been sufficient to cause an interruption to the drainage in the flat glacial plains, and I think that this influence has been partly responsible for the present existence of these lakes. I do not think that we would have had the lakes if it had not been for the effects of Pleistocene glaciation on the plateau topography, but the proximate cause appears to have been the slight earth movements operating on the ice-sheet topography.

#### 16. GEOLOGY OF THE HYDRO-ELECTRIC SCHEME.

Sufficient description has been given of the terrain of these works, and it is only necessary to summarise the conclusions that all the evidence points to. The foundation of the physiographical influences which have made the scheme possible is the uplift of the plateau in sufficiently recent times to permit the bounding escarpments to persist. This has rendered possible the existence of high-level lakes, and has given the rivers flowing over the edge of the plateau the power to erode deep gorges in close proximity to the storage sites on the higher levels.

The fact of the existence of the Great Lake itself means little to the scheme, but the fact of the wide, flat plain in which it lies is vital as a site for sufficient storage. This, as has been shown, is due, primarily, to erosion by a slowly moving ice-sheet. The slight degree of erosion by this sheet has resulted in the absence of deep morainal deposits which would have gravely militated against the construction of a

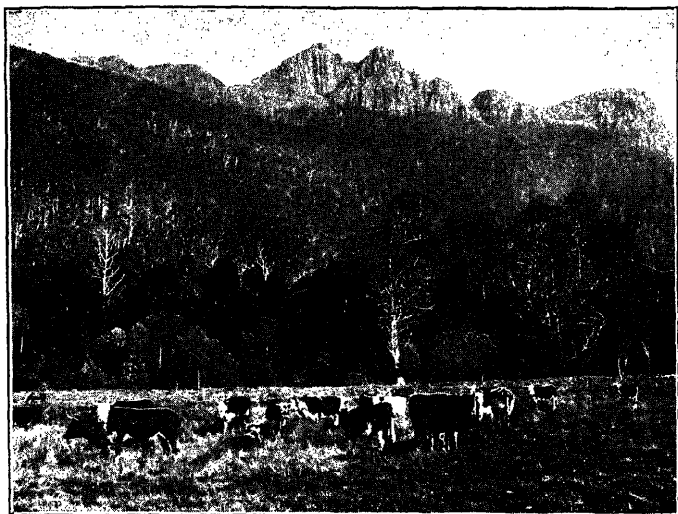
suitable dam. Thus, glacial action has been the primary factor in making the whole scheme possible.

The next consideration is the fact that the Shannon River has cut through Barren Tier, that the Ouse has also done so, but on a separate and parallel course, and that in so doing the Ouse has eroded its bed to a depth of some 1200 feet below that of the Shannon, and has done so at a spot where the divide between the two rivers does not rise appreciably above the level of the bed of the Shannon.

These factors are due principally to the headward erosion of the rivers mentioned, made possible by the fall imparted by the original uplift. Both rivers have probably found a major fault line or zone. The Shannon at the Shannon power-house flows out on to the original surface of the plateau in this vicinity, and has worked back thence to the Lagoon. The drop is 300 feet in 5 miles. This portion of its course has been eroded into a considerable gorge.

Many factors have contributed together to enable the Ouse to deepen its valley to such an extent below that of the Shannon. Opposite Swan Bay the Ouse is scarcely 100 feet below the level of the Great Lake. Ten miles down its course it is 1200 feet or so below the level of the Shannon. Twenty years ago Mr. Clemes suggested to me that this was due to the fact that the Shannon drained out of a lake, and consequently left it without sediment, and the Ouse, passing round the side of the lake, was able to commence with a considerable sediment load by the time it was opposite the source of the Shannon. My observations confirm this. The Ouse, at the Skittleballs bridge, is moving a considerable shingle load, and undoubtedly this is an important factor. But it is not the only one. The Ouse had, originally, a far greater flow of water, and, from its more westerly situation, its numerous tributaries, its barren catchment area, and the absence of considerable lake barriers in its course, is subjected to violent flooding from which the Shannon was free. More than this, the Ouse has a shorter, and more direct, course from the plateau to its lower junction with the Shannon, and, most important of all, has reached the soft Permo-Carboniferous rocks below the dolerite at a higher elevation than has the Shannon.

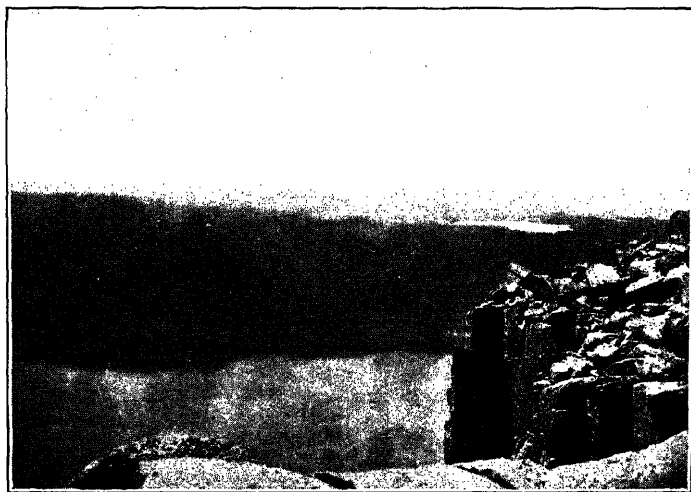
Permo-Carboniferous rocks appear in the valley of the Ouse at Waddamana at an elevation of some 400 feet above the present bed of the river, which has considerably deepened its valley in these rocks, while the Shannon is still eroding through the hard dolerite for a much longer distance. The



[Spurling, Photo.]

XXI. *Rugged Mountain from Valley of Mersey.*

This is a typical nunatak under present Tasmanian conditions, viz., bare rock above, swampy glacial valley below, dense vegetation on talus-covered slope. Rugged Mountain is the most easterly of the residual mountains of the western edge of the plateau.



[C. E. Lord, Photo.]

XXII. *The Central Plateau, looking east from Mount Olympus.*  
Lake St. Clair in the foreground, with Mount Ida beyond. Traveller Rest Lakes in right background, and Mount Ironstone on skyline to left.



Ouse found a fault-line in its lower course, and this has enabled it to penetrate the dolerite more easily. The greater angle of slope, its greater volume, and sediment load has enabled it to cut deeper into the plateau wall, and this, in turn, has given it greater power in ascending ratio. To these factors the depth of the Ouse gorge at Waddamana below the Shannon valley is due, and thus the other vital factor of the sufficient fall is present. The pipe-lines from the Shannon diversion follow the original surface of the plateau as it appeared in Pleistocene times. At no great distance in the future the Ouse would have beheaded the Shannon in the vicinity of the transmission-line to Launceston, if it had not previously drained the Great Lake just north of Murderer's Hill, in which vicinity a tributary of the Ouse approaches within half a mile of the shore of the lake at a lower elevation.

#### 17. ACKNOWLEDGMENT.

I acknowledge with gratitude the assistance of Mr. Eric Brock, of Lawrenny, who kindly drove me to the Lake Echo, at the source of the Dee, and thus enabled me to complete this paper; the services of my friend, Mr. F. C. Mitchell, in the field, and in assisting me with the plans accompanying this paper; of Mr. Spurling, for the photographs of the western portions of the area, taken on a trip he made from Mount Ironstone to Lake St. Clair; and of Mr. C. E. Lord and Mr. J. C. Breaden, for other photographs reproduced in the paper.

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VOYAGE OF THE "MARY AND SALLY" TO MAC-  
QUARIE ISLAND FOR THE PURPOSE OF OBTAIN-  
ING SEA ELEPHANT OIL AND SEAL SKINS.

(November 16, 1813—March 13, 1814.)

By

W. L. CROWTHER, D.S.O., M.B., V.D.

Plate XXI.

(Read 10th October, 1932.)

This vessel of 130 tons, Captain James Kelly, master, is noted in the "Sydney Gazette" of 18.9.32 as having left Sydney Cove for the Derwent, en route for Macquarie Island. After a stay of nearly two months at Hobart Town her voyage proper commenced on 16th November, 1813.

The brig was no stranger to the Southern Antarctic Islands, and, since her arrival from Bengal, had made voyages in the two previous years to Campbell and Macquarie Islands, under the command of Captain Feen.

At this time, two and a half years after its discovery, although the fur-bearing seal had been so depleted in numbers, Macquarie Island was still the home of large numbers of sea elephants.

The object of the voyage was primarily to obtain oil from the latter and the skins of the fur-bearing seal.

The narrative that follows is taken from a manuscript journal in the handwriting of Captain James Kelly. This came into the possession of the writer some five years ago from the widow of the late Joseph Kelly, a younger son of the captain.

Written on old hand-made paper, with ink that has kept its freshness, and bound in kangaroo-skin leather, this log is of the greatest interest.

Robert McNab, the great historian, knew of no logs bearing on sealing at Macquarie Island; and by this log, taken in conjunction with the account of the Bellinghausen Russian Expedition (<sup>1</sup>) we are able to visualise the daily routine, with the hardship and peril of the sealing gangs and the little ships that ministered to them.



On 16th November, 1813, the master of the brig writes:

"At 6 p.m. fresh breezes and cloudy, the extremes of the land West by South to North East. Tasman's Head bore N.N. East, distance 4 leagues. From which I take my departure for Macquarie Island . . . .  
I allow 12 miles set Easterly . . . ."

The last sentence is most significant. The island lies some 850 miles south and a little east of Tasmania, and the prevailing winds are westerly. Captain Kelly at that date had no instrument (chronometer) by which he could estimate his longitude; that is, his distance east or west of Greenwich.

He could estimate, however, by the sextant and by "dead reckoning" the distance south that he had travelled; that is, his latitude.

It was, therefore, of great importance to him to know what "set" he was making to the eastward, as then when he had made his proper latitude all that would be required would be for him to steer either east or west, according to his estimated position, until he made his land fall.

Sailing steadily, with light winds and cloudy weather, he notes, five days later: "I allow 9 miles set to Easterly this 24 hours."

The days passed without much incident, and on the 24th the small boat is given a coat of damm, a black shag is seen, and the weather becomes worse.

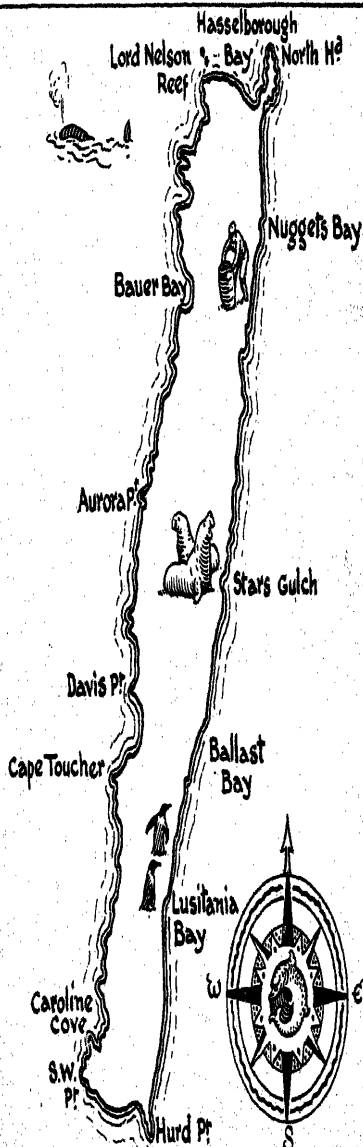
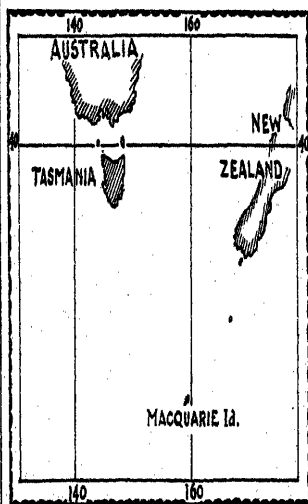
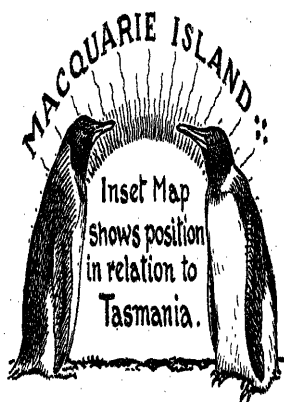
Strong gales, with heavy snow and sleet, are noted on succeeding days, until 29th November, when he wore ship to the S.W., and bore up for the island. Heavy weather and poor conditions prevented land being sighted until next day, when at noon the land was seen bearing east distance 3 leagues, at a latitude of 54° 20' south.

On 1st December, at half-past seven, the "Mary and Sally" came to with the best bower (anchor) in 13 fathoms. Her anchorage was reached by sailing past the north end and down the east coast of the island until sheltered by the land from the westerly wind. On sending a boat on shore "to look at the place, found enough Elephant to begin oiling"; and so "at daylight began to land hoops and provisions and empty casks."

On the same day nine men, with two officers, were appointed to land and procure skins and oil.









On the following day "what other stores were wanted were landed and in particular cooper's gear and stooks and hoops."

The landing party reported that they had not seen one seal (fur). Preparations were also made for landing the salt.

Here it may be said that salt was indispensable for curing the skins of the fur-bearing seal, and was mostly procured from Kangaroo Island.

It is probable that, before putting into the Derwent from Sydney, the brig may have gone to Kangaroo Island to obtain a supply.

On the ship preparations were made for rafting off the oil, and slings were made from a pair of foretopgallant stays for the same.

On shore the party was killing and procuring oil, and on the 5th ten casks, containing 630 gallons, were brought off by the boat and stowed away.

As well as killing in the neighbourhood of the works, sea elephants were being taken in Hasselborough Bay, on the western side of the north end of the island. Their blubber was rafted round by the ship's boat, which had previously landed empty casks and salt from the ship.

By the 16th of the month 70 casks of oil were stowed on board, and next day the weather changed to south-easterly, and the "Mary and Sally" had to slip her cable and run for it. The log for the day reads:

"First and middle parts light airs at N.W. Employed clearing the decks. At 4 a.m. set in fresh breezes at E. with rain. Hoisted the boat in and got a spring and slip rope on to the cable ready to run as soon as the wind should veer a little either ways, not being able to clear the land on either tacks. At 10 the wind came to S.E. by East, got all sail set, at half-past 10 cut the cable and cleared the North Head. At noon fresh gales and hazey weather, standing to the S.W. The North Head bore N.E. by E. the distance 7 miles."

After four days, the weather improving, the brig returned to her anchorage, using the small bower with 12 fathoms, but was unable to pick up the anchor she had slipped. Again the weather changed, and

"At half past 3 (a.m.) hard gales and heavy sea from the N.E. caused us to cut from our anchor and run around the South End of the Island."

Another week was passed, with hazy weather, hard gales, and continued seas, until on the 29th December the wind came to S.W., and the brig hauled round the north bluff to her anchorage.

"Hove short and got the best bower on board, hove up the small bower and secured it"—so the log reads, and it was no mean feat of seamanship either, to have secured both the anchors she had had to abandon previously.

The log makes no mention of Christmas Day for 25th December, and merely remarks on 31st December that another 34 casks of oil were got on board.

The new year (1814) commenced with weather still westerly, with the people employed on board as necessary, and on shore assisting the works. On the next day, however, came a change, and the log speaks for itself:

"Began with moderate breezes at N.W. and hazey weather at midnight wind N.N.E. Hoisted the boat in and got a slip rope and got a buoy on the cable, at 2 a.m. wind N.E. by E. Slipped the cable and ran to the S.E. At 3 strong gales, close reefed the topsails, at 5 hard gales at East, reefed the foresail. Carrying a heavy press of sail to clear the Island. With heavy rain at 6 saw the South End bearing N.W. distance 4 miles, took in all sail and ran under poles. Still blowing very hard at East, at 10 more moderate. Course W. by S. at Noon wind S.S.E. and cross sea, hove too head S.W., Latitude 54° 54'."

The next day, at 2 p.m., the wind chopped to the S.W., and blew with increasing force, and at midnight a heavy sea was shipped, but did no damage. The brig bore up for the anchorage, and "at noon got the end of the cable onboard and all things clear for receiving oil."

The anchorage from which the ship was forced to run at 2 a.m. of the previous day was the North-Eastern Bay of later navigators. Ainsworth (?) describes a gale there on 5th February, 1912, as follows:

"A tremendous sea worked up, and the ocean for the distance of a mile from the shore was simply a seething boil of foam. Hugh waves dashed onshore running yards beyond the usual marks and threatening to sweep across the Isthmus. The top of the waves could be seen flying over Anchor rock, seventy feet high and spray was blown right across the Isthmus."

One can picture the little brig, in the darkness and under such conditions, trying to work her way to windward, so as to clear the southern end of the island.

The responsibility of her master, who had to keep a sufficiency of sail and yet not lose her spars, and his relief when a safe offing had been effected, and he could order sail to be taken in and the ship allowed to run under bare poles.

A week of quiet followed, work going on all the while on shore, and on 10th January 10 hogsheads of salt were started into the captain's cabin ready to put oil into the casks.

The next day Captain Kelly came to a decision to try the west, or weather, side of the island, and, slipping his cable, ran round the northern end. With moderate breezes at S.S.E. he closed in to the land. His dual purpose was to obtain firewood from the wreck and look for fur seals.

This wreck, the first to occur on Macquarie Island, was of the "Campbell Macquarie," 248 tons, which, on 10th June, 1812, ran aground, and afterwards went to pieces. Her crew of 12 Europeans and 30 Lascars were all got ashore. She had nearly three suits of sails, and when the weather cleared up the crew succeeded in getting them on shore, where they were stored in a hut, which was afterwards accidentally destroyed by fire. All her stores were lost, independently of which she had taken on board 2000 prime skins, 36 tons of salt, and 118 tons of coal in lieu of ballast.

While on the island four of the Lascars died, also a seaman of the "Mary and Sally" (then lying there) named Thomas McGowen (?).

The ship's boat returned with the wood from the wreck, and at four went back to the cove, where 59 seal skins were procured. A further 296 skins were taken in the next 24 hours, when the brig returned by the northern route to the anchorage. At North-Eastern Bay the boat, having been stove, was sent on shore for repairs, and the skins salted.

No less than 69 casks of oil were taken on board in the three succeeding days, and the log for 18th January records:

"Cleaning out the fore peak and stowing oil. Latter part employed getting the things onboard ready to move to Ballast Bay as the Elephants is all killed at the N. end of the Island.



"All hands and boats employed in moving the pots and houses to the new location and the empty casks were also rafted along the coast. We find at Ballast Bay all the salt casks belonging to Geo. Howe, all moved from the place where they were left, appear to be washed away by the surf some a mile distant from each other and several stove with the rocks."

So reads the log of the 21st of January. Two days later the "Mary and Sally" weighed, and brought to in the bay, about half a mile from the shore, with the best bower in 15 fathoms.

After four days' westerly weather came signs of a change, until at 5.30 p.m. of 28th January a change of wind forced the brig to slip her cable and run. On the same day "the people" were put on a reduced ration of 1 lb. of bread (i.e., biscuit) per week.

This easterly weather continued for ten days, varying from strong to moderate winds, and in one squall the square mainsail was split all to pieces, as Kelly puts it, "the sail being very old and unrepairable." As a substitute the next day the foresail was bent for a mainsail. Some difficulty was experienced on 10th February in light, baffling winds, in regaining the anchorage in Ballast Bay. At daylight the next day some of the shore party came off to assist getting the anchor. The log records: "Ran a hawser to the cable, hove up the small bower and hauled the vessel to our anchor we left on the 28th of last month."

During this fortnight of easterly gales, whilst the brig was at sea, her shore party reported that, owing to bad weather, they had got but little oil and a small lot of 30 seal skins.

Preparations for leaving the island now commenced. Oil was rafted off, and in a blow from the north-west three casks, two hogsheads, and one 100-gallon cask were blown away and lost.

"Two boats gone to the North Head to bring a part of the old staves onboard and shooks. All the bad and broken staves we were obliged to burn for fire as our fire wood was all used for stowing the casks."

So runs the entry for 10th February.

The following four days were full of activity; 73 more casks of oil and four casks of fresh water were taken on

board, with a loss of one cask of oil and two of water on rafting from the beach.

The cooper was employed shaking out the empty casks to stow away.

All stores were off and stowed below, and the log for Saturday, 19th, read:

"Began with light airs and variable, employed getting all the things off from the shore and stowing same away, hoisted the boats in and stowed them and hove short, at half past seven p.m. light breezes at North, weighed and made sail, got the anchor on the gunnels, bound for the River Derwent.

"At midnight North End of the Island bore West 5 miles from which I take my departure."

The little brig, heavily laden, made her way slowly to the northward towards home.

Strong gales were experienced, and on the second day's run, at half-past 3, a heavy sea was shipped, which stove the boat over the stern. No other damage was received, however.

Her progress was slow, and it was not until 8th March (18 days from leaving Macquarie Island) that Van Diemen's Land was sighted. On that day, at 3 p.m.: "Saw Oyster Ild. W. by N. 7-8 leagues. The brig was shipping and making a lot of water in the hard gale."

During the next two days Oyster Island was still abeam, but on 9th March, at sunset, Cape Pillar was S. by W., 10 miles, and at daylight the next day, with a course S. by E., Oyster Island bore W. by S., distance 8 miles.

Two days later the log ends with the "Mary and Sally" "running for Cape Pillar, at 4 Cape Pillar bore N. by E. distance 1 mile. Increasing breeze, clear weather."

McNab (†) reports her return to Sydney on 20th January, 1813, with a cargo of 80 tons of elephant oil, got in three months at Macquarie Island.

It is reasonable to assume that most of the intervening time was spent at Hobart Town, where no port records for so early a time remain in existence.

Of the subsequent history of this stout little brig I have no record, but Captain James Kelly from about this date must have commenced his long association with Hobart.

Town and Van Diemen's Land. An association which was to bring him fame and honour as a pioneer explorer and discoverer of Port Davey and Macquarie Island, and to afford him place and power as a harbourmaster and owner of a fleet of whaling vessels, and, in his latter days, such reversal of fortune as to cause him to petition the Governor of the day for a position as wharfinger to the splendid port of Hobart Town, to the development of which he had done so much.

## REFERENCES.

- (<sup>1</sup>) MURIHIKU, Robert McNab, p. 190 *et seq.*
- (<sup>2</sup>) MAWSON, "The Home of the Blizzard," II., p. 183.
- (<sup>3</sup>) MURIHIKU, Robert McNab, p. 128.
- (<sup>4</sup>) *Ibid.*, p. 269.

The nomenclature of the map of Macquarie Island is taken from "The Home of the Blizzard," by Sir Douglas Mawson. The map itself is the able work of Capt. D. C. Pearse, M.C.

# LETTERS OF JOHN MARTIN, THE IRISH POLITICAL PRISONER.

By

MRS. J. A. MCELROY.

(Communicated by Dr. W. L. Crowther.)

(Read 10th October, 1932.)

Some months ago there was handed to me from St. George's Rectory, Hobart, a small packet, on which was written "Old Tasmanian Letters from Dr. C. . . . ." It was naturally supposed they were connected with the early history of the church (St. George's, Battery Point, Hobart), in which I was much interested. I looked forward eagerly to reading them, thinking they might have to do with the dispute between Sir John Franklin and Captain Montagu over building the tower. They might contain a note from Lady Franklin when she sent her five guineas towards a peal of bells, which, alas, never materialised. They might even be part of that very willing theological controversy between Bishop Nixon and Dr. Henry Phibbs Fry!

A glance at the first letter dispelled all my hopes; the address was one from which no governor or his lady, or bishop or his clergy, was likely to write. It was a Dublin jail, and the writer was John Martin, the editor of the "Irish Felon" newspaper, who for sedition and conspiracy had been sentenced to transportation for 10 years! The letters, with the exception of one from his mother to his brother David, were all in his handwriting.

The only early connection St. George's had with Dublin was through Dr. Fry, who was a graduate of Trinity College, at which institution John Martin had begun his never completed medical course; and from the dates these two might have been there a short time together. They were certainly contemporaries in Tasmania, and it was from Dr. Fry's parish, and through one of his churchwardens, that John Mitchell, one of Martin's fellow prisoners, made his escape.

But these suppositions proved to be groundless, and a recent letter in reply to mine, from the Rev. T. Quigley, now of Felixstowe, England, states these letters were sent to him by Dr. Crossley, of Bulli, New South Wales, some years ago, who found them in his mother's house in the north of Ireland, and who wished them to be given to some society or library in Tasmania on account of their historical value.

Some people hold the opinion that any letters relating to the convict system in Tasmania are better burnt than preserved. It was a very natural and reasonable opinion for the colonists of 1852, who had fought hard and made sacrifices in order that that system should cease, but now, after the lapse of 80 years, when the sting has died out of the question, and we are able to view it more dispassionately and impersonally, in the interests of historical accuracy it is wiser that such letters should be placed in the care of some reputable society where they can be studied by those really interested. Furthermore, the period covered by these letters—1843 to 1854—is one of the most stirring and interesting in Tasmanian history, and now that the writers of fiction are getting busy with it, it is good that any records which help to produce such a well-documented novel as the Sydney one, "A House Is Built," should be preserved. A recent Tasmanian novel centres round a church and the building of a bridge. No doubt visitors to Richmond will inspect the church there, and mentally reconstruct the opening scenes of the book, quite unconscious of the fact that it was not till some 10 years after the bridge was built that the church was erected. They will then look at the present rectory, and imagine the unhappy chaplain of the story flitting through its rooms, quite unconscious also that Richmond had no resident chaplain when the bridge was built, and that the present rectory was formerly the residence of the medical superintendent!

In such a way do legends arise.

There are doubtless many letters, and even diaries, of historical interest and value stored away and half-forgotten in Tasmanian homes.

If, as is quite natural, the owners would not care to give the originals to the Royal Society, why not give copies, and start an "Historical Letter Book"? Only last year, I believe, the diary of a former chaplain at Norfolk Island was lost when the owner's house was destroyed by fire and he himself

died. A copy of such, lodged with the Royal Society, would have at least mitigated the loss.

In 1848 John Martin was a member of the Young Ireland party; a party which repudiated O'Connell's scheme for the repeal of the Union by constitutional methods, and advocated, chiefly through their newspapers, separation by force of arms.

Smith O'Brien attempted to raise the peasantry in a revolt, which failed, and he was condemned to death for treason, which sentence was afterwards commuted to transportation. John Mitchell, of the too-fluent pen, called on his countrymen to rise in "The United Irishmen," and when he was transported for sedition John Martin carried on the work in the "Irish Felon" newspaper, till he too was convicted and sentenced to transportation. The other additional members of the party who were sent to Tasmania were Meagher, McManus, O'Donohoe, and O'Doherty. Their story in Tasmania has been sympathetically told by the Rev. J. H. Cullen in "Young Ireland in Exile," and Fenton in his history has devoted a whole chapter to them, making large use of extracts from Mitchell's "Jail Journal" and letters.

John Martin came from Northern Ireland, from County Down; he was a Presbyterian, and on that account was nicknamed "John Knox" by his fellow prisoner and travelling companion, O'Doherty.

One would like to know the history of the change of an Ulsterman into a red revolutionary. He went to Dublin, to Trinity College, to study for medicine, and in the packet there is a letter to his young brother David, written, I conclude, by his mother on a visit there. She was evidently a cultured woman, for she regrets the heavy rain stopped them from going to see Trinity College library. She jestingly tells the boy she has seen the waxworks, with his favourite historical character, Henry VIII., and Elizabeth, whom he doesn't like, and later on she says he ought to be reading history with his elder sister Mary in the evenings. He must have been quite a small boy then, for she hopes that he washes and combs himself every day. It seems this mother must have died, as apparently had the father, for there is no mention of her at all in John Martin's letters; and yet this little glimpse of his Dublin student days gives a picture of happy companionship and affectionate care between mother and son.

Perhaps she was anxious for his future even then, and made this, her first, visit to Dublin for his sake, where she tells the young boy at home she has seen more people than she ever saw before, and things which will be better told by the fireside than compressed into letters.

What may be taken to be the first of John Martin's letters, for the year is not given, is written from Mount-street, Dublin, and concerns the result of an election for which the League was unprepared.

The second is headed "Richmond, Birdewill, Dublin, June 3rd, 1849," where he and his companions are awaiting sentence, and tells how news has arrived of Sir Lucius O'Brien's interview with Sir George Grey, the Colonial Under-Secretary, when he was informed that his brother, Smith O'Brien's, sentence had been commuted to transportation for life, and also that the convict ship "Mount Stewart Elphinstone" would call at Dublin that week to convey prisoners to Hobart Town, Van Diemen's Land. They had not expected to be sent so far away, and thought it more likely that they would join Mitchell at Cape Town. As we know from the "Jail Journal," the colonists at this place refused to receive transported convicts, and Mitchell was sent on to Tasmania.

The next, a longer letter, written three weeks later, is dated from "On board the Mount Stewart Elphinstone, Cork Harbour," where the pilot had just come aboard, and he and O'Doherty were setting out for Sydney without their four other companions in exile, as they hoped.

He says:

"We will have quite a roomy, snug cabin for reading in. The people on board are all quite civil with us. Even the poor doctor, though a ridiculous, troublesome martinet, is not desirous to annoy us, I think, but the contrary. . . .

"Our voyage is turning out expensive enough—£20 each at least—though we have all resolved to be at no expense for it. It was not on account of the quality of the food we would have as rations that we preferred making a bargain with the captain for our mess. The food that the common convicts get would be good enough I'm sure. But how could we manage to cook it, &c. Besides, we will be more civilly treated by the captain and other officials on account

of our arrangement with him. And any comfort that a little money can procure us, I have no objection to take from officials."

This paragraph is quoted to show under what comfortable conditions these two prisoners travelled, for it is often supposed they shared the hardships of those he terms "common convicts," probably transported for far less serious crimes than "sedition" and "conspiracy."

Martin's strong family affection is evidenced in this farewell letter. He hopes that David will marry, and marry young, and when writing later from Bothwell, on more than one occasion he gives the same advice—"Don't leave it too late"—"find some good girl"—"and children of course." He concludes:

"In bidding you farewell for a few years, my dear brother, I have but to beg that you will think hopefully of me; that you will continue to make honour and principle the guide of your conduct, that you will never forget that *God sees us*. I trust to see you again, and that before many years, and to live many happy years in free intercourse with you and all the members of my family. Surely no man ever received more affectionate care and support from all the members of his family than I have from all mine. God bless you, my dear brother."

It is disappointing to find the next two letters missing: one describing the voyage, posted at Sydney, and one written to his sister Mary soon after his arrival at Bothwell, both of which he speaks of in a letter to David dated from there on 16th November, 1849.

In it he describes the township, the valley of the Clyde, the surrounding country, his lodgings at £1 a week, and his landlady, Mrs. Harris, "the friend of your friend Sairy Gamp." Though he has only been in the country a fortnight he has already found the point where the police districts of Bothwell and Oatlands touch, and at a two-storey red brick house on the Jordan, "Pleasant Place," has met O'Doherty, his companion on the voyage from Ireland.

It is somewhat surprising how these Irishmen took so easily to cross-country riding through the bush, and, as the "Jail Journal" shows, their excursions to Lake Sorell were among the happiest incidents recorded. Later on, when John Mitchell was sent to Bothwell and joined by his wife and children, the whole company moved to Nant Cottage. Mitchell



was supposed to be farming, but Martin records that he was not taking it seriously, and in the last year had put in no crops. Exciting plans for various escapes, stolen visits to other districts, news from Ireland and America, left little time for hum-drum agricultural work.

It was difficult for Martin to earn a living in a country township, and yet these men had to be sent to inland districts to lessen the possibility of escape. So he took up the only thing he could, the teaching of some of the landowners' sons, and did not find it very congenial. And here he met another strange schoolmaster, in charge of the State school in the township—"Mr. Frost, the Chartist leader, sentenced to be hanged for treason in 1839, and whose sentence was commuted to transportation. I have seen him twice," he says, "and had plenty of talk with him. He has met remarkably harsh treatment compared with ours, and yet it seems that he was always very submissive and respectful to the English Government people. It is only within three years (I think) that he has got a ticket-of-leave, and previously he was under probation like any common convict, and working on the Government road in chains. I don't understand all this. He is a stout, hale man of 63. All he begs for is a conditional pardon which would enable him to go to any place except the United Kingdom. He would go to America, and Mrs. Frost would meet him there. Is it not a striking proof of the English Government's consciousness of their iniquity against my country that they treat us sturdy Irish rebels so leniently?"

This passage is quoted in full because some people believe the Irish prisoners were very harshly treated, a belief which may have its origin in the exaggerated language of Mitchell. He frequently speaks of "our dungeon," meaning either the wide, pleasant country round Bothwell, or the whole island of Tasmania, and even before he has seen it refers to Hobart as "that metropolis of murderers, and university of burglary, and all subterhuman abomination."

In comparing Frost's sentence and treatment with theirs, one has to remember that the Chartist risings were attended with bloodshed and great destruction of property, while though Young Ireland called upon the peasantry to rise and free their country from the British yoke, the peasantry very wisely went quietly home. Also one is compelled to consider the fact that some of the Young Irelanders had influential relations in the English Parliament.

For David's information Martin gives current prices at the time of the gold rush to the mainland:

"Draught or freight from here to Hobart Town for six or seven months is £6 to £7 a ton, the distance being 46 miles.

"Draught colts £50 to £100 each, oats 16s. a bushel, potatoes £20 a ton.

"The decent man, my neighbour, grumbles because he has to pay 20s. per hundred for his sheep-shearing instead of 9s. or 10s., and £40 to his shepherd instead of £18 or £20."

References to friends and relations at home, to political events in Ireland, America, and descriptions of Tasmanian scenery make up the rest of the letters.

The whole of the Irish incident in Tasmania was over in little more than five years; four of the prisoners had escaped, the rest were pardoned.

In Fenton's history, after mentioning Martin's pardon in 1854, we read: "He then went home—but to die." This is what one might call exaggerated language, as John Martin did not die till 1875, 21 years after his release, and in that time he did a good deal besides dying.

I have heard it stated, but cannot vouch for the truth, that this chapter on the Irish prisoners in Fenton's history was not written by Fenton himself, but by some one more in touch with them.

The heading of the last letter in the packet is a far cry from the township of Bothwell; it is Paris (France), 29th April, 1859, the letter of a sick and weary man, vexed with the haphazard ways of his sister's family, and "still more angry at myself for being angry."

Paris is humming with excitement, the Italian war of liberation is on, the French army is in marching order, and Martin stands outside the Tuilleries in the crowd that watches the regiments march past the Emperor. He hears the shout of "Vive L'Empereur! Vive L'Italie!" and joins in the cry from his heart.

"Vive L'Empereur!"—a strange salute from Young Ireland to the man who in the end wavered and sent his French soldiers to break Garibaldi's army at Mentana, and so delayed the triumph of United Italy!

And last of all there is an epilogue to these letters, in the form of a passport of 1867 for travelling on the Continent "for Mr. David Martin, British subject, accompanied by his wife." David had evidently listened at last to his brother's oft-repeated advice, made "the sound investment," and found "the good woman"!

# The Royal Society of Tasmania

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## Abstract of Proceedings 1932

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4TH MARCH, 1932.

### *Annual Meeting.*

The Annual Meeting was held at the Society's Rooms, Tasmanian Museum, on the 4th March, 1932, Dr. W. L. Crowther presiding.

The following were elected Members of the Council for 1932:—Dr. A. H. Clarke, Mr. W. H. Clemes, Dr. W. L. Crowther, Mr. E. T. Emmett, Mr. V. V. Hickman, Dr. A. N. Lewis, Mr. L. Rodway, Mr. E. E. Unwin, Mr. F. E. Ward, Mr. Clive Lord (*ex officio*).

Mr. Walter E. Taylor was elected Honorary Auditor.

Mr. S. Angel was elected a Member.

### *Illustrated Lecture.*

Commander Moyes, of the H.M.A.S. Australia, delivered an illustrated lecture on "Recent Antarctic Exploration."

5TH APRIL, 1932.

A meeting was held at the Society's Rooms, Dr. W. L. Crowther presiding.

It was announced that the President had appointed Dr. W. L. Crowther and Dr. A. N. Lewis as Vice-Presidents for 1932.

The following Members were elected:—Mr. A. S. Johnston, Mr. H. J. Read, Mr. John Lord, Miss E. Dumaresque, Miss T. Cook, Mr. J. R. Skemp, Dr. B. Anderson, and Rev. W. T. Reeve.

The meeting was held in connection with Adult Education Week, and the following lecturettes were given:—

Tasmanian Geology—Dr. A. N. Lewis.

Tasmanian Botany—Mr. E. E. Unwin.

Tasmanian Zoology—Mr. V. V. Hickman.

Tasmanian History—Mr. Clive Lord.

16TH MAY, 1932.

A meeting was held at the Society's Rooms, Dr. A. N. Lewis presiding.

Reference was made to the death of Mr. Gustav Weindorfer, of Waldheim, Cradle Valley, and a vote of condolence passed.

The following Member was elected:—Mrs. W. L. Crowther.

*Illustrated Lecture.*

Mr. F. Smithies delivered an illustrated lecture on a trip to the summit of the Frenchman's Cap.

16TH JUNE, 1932.

A meeting was held at the Society's Rooms, Dr. A. N. Lewis presiding.

The following Members were elected:—Mr. D. Ockenden and Miss N. Kennedy.

An exhibition of early Tasmanian publications, maps, and sketches was held in the Library, and lecturettes on certain aspects of the exhibits were delivered by Dr. Lewis, Mr. Unwin, Mr. Henry Allport, and Mr. Lord.

11TH JULY, 1932.

A meeting was held at the Society's Rooms, Dr. W. L. Crowther presiding.

Election of Members: Mr. F. D. Maning and Miss J. Somerville.

*Illustrated Lecture.*

Mr. E. E. Unwin, M.Sc., delivered a lecture on "The Aquatic Habits of Insects."

8TH AUGUST, 1932.

A meeting was held at the Society's Rooms, Dr. A. N. Lewis presiding.

*Illustrated Lecture.*

Mr. V. V. Hickman, B.A., B.Sc., delivered a lecture on the Biology of Spiders.

12TH SEPTEMBER, 1932.

A meeting was held at the Society's Rooms, Dr. W. L. Crowther presiding.

Election of Member: Mr. D. H. Harvey.

*Leonard Rodway, C.M.G.*

The following resolution, moved by the Chairman, was passed:—

"That the Royal Society of Tasmania desires to place on record its keen appreciation of the exceptional services of Mr. L. Rodway, C.M.G., in the interests of science, and an expression of deep regret that circumstances have arisen which compel Mr. Rodway to relinquish his position as Honorary Government Botanist, a post which he has held for so many years, during which he has performed services of great value to the State."

Dr. Crowther said that the value of the work done by Mr. Rodway was incalculable. His work fell under three headings—professional work as a dental surgeon; work as Government Botanist, especially in the matter of noxious weeds; and his monumental monographs on the flora and the mosses of Tasmania. His influence on the men around him, particularly the younger generation, had been marked. He had reached the highest position as a dental surgeon, but his professional work had often had to give way to his principal work, which was the science of botany. Every worker in the field of science in this State would find himself indebted to Mr. Leonard Rodway.

Dr. A. N. Lewis, M.H.A., seconded. He said he had come particularly under Mr. Rodway's influence in his younger days. The saddest feature in Mr. Rodway's resignation was that there was no one else in the whole community exactly able to fill his place.

Mr. E. E. Unwin added his personal testimony. He had come to this State nine years ago, without any knowledge of the flora of this part of the world, and had found in Mr. Rodway a generous friend and helper.

The Director of Agriculture (Mr. F. E. Ward) spoke of the very valuable help that Mr. Rodway had given to the Agricultural Department.

The motion was agreed to.

*The Position of the Society.*

The position of the Society was discussed, particularly in view of the fact that the Government had eliminated the vote in aid of printing the papers and proceedings of the Society.

Mr. Unwin said that he felt that a strong case could be put forward for such institutions as the Royal Society, the Tasmanian Museum, and the Botanical Gardens not being deemed charitable bodies. As such they were under a wrong classification. They should be grouped with the educational bodies of the State, which were being reduced very differently. For primary education the reduction was 3 per cent.; for the University, 2 per cent.; and for technical education less than 3 per cent. Such reductions were, of course, serious, but in proportion not so serious as in the case of the Royal Society, which had been deprived of the whole of the vote, and was faced with an acute dilemma. The Society depended upon the exchange of its publications to obtain those of learned bodies in other parts of the world. They had a very valuable library, a wonderful heritage, but it needed to be kept up to date by the inclusion of foreign publications. The membership of the Society was not large enough to carry the whole responsibility. The Royal Society of Tasmania could look back on 89 years of continuous existence. It was the only society outside the homeland with such a glorious record. They were shutting up avenues, and preventing men from doing research work. There might be other Leonard Rodways waiting for encouragement which no one could supply, because papers could not be published. There were the Royal Society medal and the Johnston Memorial medal; but they did not dare to invite learned men to speak, for they had no means of publishing the proceedings. He moved:

"That this meeting requests the Council of the Royal Society to bring under the notice of the Government the past history of the Society in its relation to the present position of its reference library and the general position of the Tasmanian Museum."

The motion was agreed to.

*Lecture.*

Mr. J. D. McElroy delivered a lecture on "Oil, with special reference to its influence on commercial development."

10TH OCTOBER, 1932.

A meeting was held at the Society's Rooms, Dr. A. N. Lewis presiding.

*Papers.*

"Aboriginal Rock Carvings in Tasmania," Part 2, by A. L. Meston, M.A.

"Notes on the Letters of John Martin," by Mrs. J. A. McElroy.

"Notes on the Early Development of Macquarie Island," by W. L. Crowther, D.S.O., M.B.

*Lecture.*

Dr. Crowther delivered an illustrated lecture on Macquarie Island.

9TH DECEMBER, 1932.

A meeting was held at the Society's Rooms, Dr. A. N. Lewis presiding.

Mr. M. W. Carne was elected a Member.

The Chairman explained that the meeting had been called as the result of certain letters which had appeared in the press concerning the Botanical Gardens, and the deputation to the Government on the same matter. Members of the deputation, and critics of the present policy of the Trustees, had also been invited in order that they might place their views before the meeting.

Mr. W. H. Clemes, Chairman of Trustees, gave a resume of the proceedings which had led up to the present position. He explained in detail the position of the Gardens and the policy of the Trustees. He pointed out that the Trustees were endeavouring, in spite of their very limited financial resources, to make the Botanical Gardens a Botanical Garden in effect as well as in name. After dealing with all aspects of the present position, Mr. Clemes moved:

"That this Society approves of the actions of its representatives on the Board of Trustees, which have the approval and confirmation of this meeting."

The resolution was seconded by the Hon. L. M. Shoo-bridge, M.L.C. Dr. E. A. Elliott, Messrs. N. Oldham, and



W. Osborne, members of the deputation to the Government, gave their views on the matter. Mr. I. Boas, M.Sc., Chief Forestry Officer for the Council of Scientific and Industrial Research, was invited by the Chairman to speak. Mr. Boas said that during the course of his visit to Hobart he had examined the Botanical Gardens, and had formed the opinion that the Trustees were acting on correct lines. If anything a more extensive trimming of the overcrowded section should be carried out. The criticism was not justified.

Messrs. E. E. Unwin, E. T. Emmett, A. V. Giblin, F. E. Ward, S. W. Steane, C. Lord, and Drs. Crowther and Lewis also spoke.

The general tenor of the discussion showed clearly that the Trustees' policy was a distinct benefit to the Gardens, and had the approval of botanical experts. Further, it was clear that the criticisms which had been made were based upon a want of knowledge of the true conditions. The resolution expressing confidence in the Trustees, and approval of their actions, was carried without a dissenting vote.

# The Royal Society of Tasmania

## 1932

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Patron:

HIS MAJESTY THE KING.

President:

HIS EXCELLENCY SIR HERBERT NICHOLLS, K.C.M.G.

Vice-Presidents:

W. E. L. CROWTHER, D.S.O., M.B., V.D.

A. N. LEWIS, M.C., LL.D.

Council:

(Elected March, 1932)

W. H. CLEMES, B.A., B.Sc. (Chairman)	A. N. LEWIS, M.C., LL.D.
A. H. CLARKE, M.R.C.S., L.R.C.P.	CLIVE LORD, C.M.Z.S.,
W. E. L. CROWTHER, D.S.O., M.B.,	F.L.S., F.R.A.I.A.
V.D.	L. RODWAY, C.M.G.
E. T. EMMETT	E. E. UNWIN, M.Sc.
V. V. HICKMAN, B.A., B.Sc.	F. E. WARD

Standing Committee:

W. H. CLEMES, A. N. LEWIS, CLIVE LORD.

Hon. Treasurer:

A. N. LEWIS.

Editor:

CLIVE LORD.

Auditor:

WALTER E. TAYLOR, F.F.I.A., F.I.A.S.

Secretary and Librarian:

CLIVE LORD.

# List of Members

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## Honorary Members.

- David, Sir T. Edgeworth, K.B.E., C.M.G., B.A., F.R.S., F.G.S., Emeritus Professor of Geology and Physical Geography in the University of Sydney, 49 Burdett Street, Hornsby, N.S.W.
- Mawson, Sir Douglas, Kt., O.B.E., B.E., D.Sc., F.R.S., Professor of Geology and Mineralogy, The University, Adelaide.
- Wood-Jones, Professor F., M.D., D.Sc., M.R.C.S., L.R.C.P., F.R.S., The University, Melbourne.
- Tillyard, R. J., M.A., Sc.D. (Cantab.), D.Sc., F.R.S., F.N.Z. Inst., F.L.S., F.G.S., F.E.S., C.M.Z.S., Chief of the Division of Economic Entomology, C.S.I.R., Canberra City, F.C.T.

Year of  
Election.

## Corresponding Members.

- 1901 Benham, W. B., M.A., D.Sc., F.R.S., F.Z.A., Professor of Biology, The University of Otago, Dunedin, N.Z.
- 1892 Bragg, Sir W. H., M.A., F.R.S., Director of the Royal Institution, Albemarle Street, London.
- 1901 Chapman, Professor R. W., M.A., B.C.E., The University, Adelaide.
- 1923 Pulleine, R., M.B., 163 North Terrace, Adelaide.
- 1892 Thomson, Hon. G. M., M.L.C., F.L.S., 99 Eglinton Road, Dunedin.
- 1901 Wall, Professor A., M.A., Canterbury College, Christchurch.

## Life Members.

- 1918 Avery, J., Private Bag, Hobart.
- 1809 Baker, H. D., American Consular Service, Washington.
- 1890 Foster, Lt-Colonel Henry, "Merton Vale," Campbell Town.
- 1905 Grant, C. W., Senator, "High Peak," Huon Road.
- 1896 Sprott, G., M.D., Town Hall, Hobart.

Year of  
Election.

## Members.

- 1931 Agnew, Mrs., 2 Waverley Avenue, Augusta Road, New Town.
- 1921 Anderson, G. M., M.D., C.M., 56 Clare Street, New Town.
- 1921 Allen, D. V., B.Sc., Technical School, Launceston.
- 1928 Allport, Henry, LL.B., 111 Macquarie Street, Hobart.
- 1932 Angel, S., Commercial Bank of Aust., Hobart.
- 1926 Atkins, C. N., M.B., B.S., D.P.H., 145 Macquarie Street, Hobart.
- 1928 Avery, David, Geeveston, Tasmania.
- 1921 Baker, Hon. H. S., LL.M., D.S.O., Messrs. Finlay, Watchorn, Baker, and Turner, Murray Street, Hobart.
- 1921 Barr, J. Stoddard, M.D. (Glasgow), Lower Sandy Bay.
- 1926 Barrett, Rev. W. R., Christ College, Park Street, Hobart.
- 1929 Baudinet, Miss D., 336 Murray Street, Hobart.
- 1931 Bell, Miss D., 302 Argyle Street, Hobart.
- 1924 Bennett, H. W., L.D.S., D.D.S., Brisbane Street, Launceston.
- 1909 Blackman, A. E., 26 Warwick Street, Hobart.
- 1920 Blaikie, T. W., Practising School, Elizabeth Street, Hobart.
- 1927 Blake, Frank, Red Chapel Road, Lower Sandy Bay.
- 1928 Bowling, J., "Barrington," Tower Road, New Town.
- 1924 Booth, N. P., Messrs. Cadbury-Fry-Pascall Ltd., Claremont.
- 1925 Bowerman, Captain, Marine Board, Hobart.
- 1923 Breaden, J. C., 12 Waverley Avenue, New Town.
- 1922 Brownell, C. C., 117 Hampden Road, Battery Point.
- 1907 Brownell, F. L., "Berwyn," Mercer Street, New Town.
- 1928 Buchanan, Howard, E.S. and A. Bank, Hobart.
- 1929 Burbury, A. W., M.H.A., Austin's Ferry.
- 1918 Burbury, Charles, "Brookside," Moonah.
- 1925 Butler, A. L., Lower Sandy Bay.
- 1931 Butler, C. T., Red Chapel Road, Sandy Bay.

Year of  
Election.

- 1923 Butler, Mrs. G. H., 30 Augusta Road, New Town.
- 1930 Butler, Terence, M.R.C.S., L.R.C.P., Macquarie Street, Hobart.
- 1909 Butler, W. F. D., B.A., M.Sc., LL.B., Bishop Street, New Town.
- 1931 Campbell, C. J., 135 King Street, Sandy Bay.
- 1920 Cane, F. B., 90 High Street, Sandy Bay.
- 1932 Carne, W. M., 64 York Street, Sandy Bay.
- 1929 Chambers, V. I., LL.B., 22 Murray Street, Hobart.
- 1929 Chapman, G. T. F., 212 Davey Street, Hobart.
- 1928 Chapman, Miss Joi, 212 Davey Street, Hobart.
- 1931 Chepmell, C. H. D., Legislative Council, Hobart.
- 1927 Cherry, P. J., Burnie.
- 1920 Clark, W. I., M.B., Macquarie Street, Hobart.
- 1896 Clarke, A. H., M.R.C.P., L.R.C.P., "Private Secretary's Cottage," The Domain, Hobart.
- 1918 Clarke, T. W. H., "Quorn Hall," Campbell Town.
- 1910 Clemes, W. H., B.A., B.Sc., Clemes College, New Town.
- 1931 Clemes, Miss Joan, Clemes College, New Town.
- 1922 Collier, J. D. A., The Tasmanian Public Library, Hobart.
- 1932 Cook, Miss T., 6 Boa Vista Road, New Town.
- 1927 Cooper, S. G., 5 Main Road, New Town.
- 1931 Cox-Taylor, Colonel J. H., D.S.O., St. Helens, Tasmania.
- 1930 Crace-Calvert, W. F., 32 View Street, Sandy Bay.
- 1930 Crane, J. R., 17 Darcy Street, Hobart.
- 1911 Crowther, W. E. L., D.S.O., V.D., M.B., Macquarie Street, Hobart.
- 1932 Crowther, Mrs. W. E. L., "Coreen," Macquarie Street, Hobart.
- 1918 Cummins, W. H., A.I.A.C., The Telegraph Newspaper Co., Brisbane.
- 1927 Dallas, K. M., The University, Hobart.
- 1919 Davies, H. Warlow, 22 Augusta Road, New Town.

Year of  
Election.

- 1924 Davies, G. B., 111 Patrick Street, Hobart.
- 1908 Dechaineux, L., Technical College, Hobart.
- 1932 Dumaresq, Miss E., Alexandra Hospital, Hobart.
- 1919 Elliott, E. A., M.B., Ch.M., Main Road, New Town.
- 1921 Emmett, E. T., Director of Tasmanian Government  
Tourist Bureau.
- 1918 Evans, L., Department of Agriculture, Hobart.
- 1931 Evans, G. H., Hydro-Electric Commission, Hobart.
- 1921 Exley, H. J., Box 67E, G.P.O., Hobart.
- 1921 Eyre, H., Boys' Welfare School, Elizabeth Street,  
Hobart.
- 1921 Fox, Miss, Ladies' College, Launceston.
- 1930 Fox, Stanley, 131 Macquarie Street, Hobart.
- 1918 Fletcher, C. E., M.A., Education Department, Hobart.
- 1928 Foley, J. C., Weather Bureau, Hobart.
- 1921 Forward, J. R., Public Library, Launceston.
- 1927 Gellibrand, W. T., "Lachlan Vale," The Ouse, Tas-  
mania.
- 1922 Giblin, A. V., King Street, Sandy Bay.
- 1923 Gorringer, J. A., Kempton, Tasmania.
- 1926 Giblin, R. W., F.R.G.S., F.R.C.I., 69 Courtfield Gardens,  
London, S.W.
- 1921 Giblin, W. W., C.B., V.D., M.R.C.S., L.R.C.P., Mac-  
quarie Street, Hobart.
- 1908 Giblin, Major L. F., D.S.O., B.A., Ritchie Professor of  
Economics, The University, Melbourne.
- 1931 Gibson, Stuart G., M.B., B.Sc., Macquarie Street,  
Hobart.
- 1930 Giles, L., 80 Collins Street, Hobart.
- 1932 Grace, W. L., B.A., Dip. Ed., F.R.G.S., M.R.S.T., 6  
Mortimer Avenue, New Town.
- 1930 Graham, W., The Grange, Brown's River Road.
- 1927 Grant, H. N., The Tasmanian Club, Hobart.
- 1929 Grueber, F. W., 71 Arthur Street, Hobart.
- 1928 Gunn, Miss I., "Invercarron," Broadmarsh, Tasmania.
- 1924 Hall, E. L., 38 Lyttleton Street, Launceston.

Year of  
Election.

- 1922 Halligan, G. H., F.G.S., "Uplands," Station Street,  
Pymble, N.S.W.
- 1931 Hamilton, Bruce, M.B., Ch.M., Macquarie Street,  
Hobart.
- 1918 Harrap, Lt.-Colonel G., Launceston.
- 1932 Harvey, D. H., "Colwyn," 38 Main Road, Sandy Bay.
- 1931 Harvey, R. C., 115 King Street, Sandy Bay.
- 1919 Hay, Rt. Rev. R. S., D.D., "Bishops court," Hobart.
- 1931 Hawker, Mrs., 10 Elboden Street, Hobart.
- 1924 Heritage, F. W., Collins Street, Hobart.
- 1921 Heritage, J. E., Frederick Street, Launceston (3 St.  
Canice Road, Sandy Bay).
- 1921 Heyward, F. J., F.R.V.I.A., 43 Lyttleton Street, Laun-  
ceston.
- 1915 Hickman, V. V., B.A., B.Sc., 69 Cross Street, New  
Town.
- 1914 Hitchcock, W. E., 89 Balfour Street, Launceston, Tas-  
mania.
- 1918 Hogg, G. H., M.D., C.M., 37 Brisbane Street, Laun-  
ceston.
- 1931 Hughes, T. D. H., Court of Requests, Launceston.
- 1923 Hungerford, Mrs., "Hathaway House," Holebrook  
Place, Hobart.
- 1909 Hutchison, H. R., 1 Barrack Street, Hobart.
- 1932 Hytten, Professor T., M.A., The University, Hobart.
- 1928 Ireland, F. W. J., M.B., C.M., Macquarie Street,  
Hobart.
- 1919 Jackson, G. A., 97 Collins Street, Hobart.
- 1929 Jaques, G. A., Union Bank, Hobart.
- 1906 Johnson, J. A., M.A., Teachers' College, Hobart.
- 1929 Johnson, Norman, Athenæum Club, Hobart.
- 1929 Johnson, W. R., Clemes College, New Town.
- 1932 Johnston, A. S., The Friends' School, Hobart.
- 1922 Johnston, J. R., Murray Street, Hobart.
- 1922 Kemp, Andrew, Stoke Street, New Town.
- 1930 Kemp, E. D. F., Earl Street, Sandy Bay.

Year of  
Election.

- 1924 Kennedy, J., 96 Montpelier Road, Hobart.
- 1924 Kennedy, Mrs. J., 96 Montpelier Road, Hobart.
- 1932 Kennedy, Miss N., 174 Macquarie Street, Hobart.
- 1927 King, C. S., 12 Swanston Street, New Town.
- 1927 Kirby, E. R., 13 Mortyn Avenue, Hobart.
- 1918 Knight, C. E. L., Claremont.
- 1927 Knight, F. C. E., Claremont.
- 1918 Knight, J. C. E., Claremont.
- 1931 Lane, Lt.-Colonel D. A., V.D., Forestry Department, Hobart.
- 1924 Legge, R. W., Cullenswood, Tasmania.
- 1887 Lewis, Sir N. E., K.C.M.G., M.A., B.C.L., LL.B., Augusta Road, Hobart.
- 1919 Lewis, A. N., M.C., LL.D., "Abernant House," Holebrook Place, Hobart.
- 1928 Lewis, Mrs. A. N., "Abernant House," Holebrook Place, Hobart.
- 1926 Lindon, Mrs. L. H., "Waimu," Canice Road, Sandy Bay.
- 1912 Lord, Clive E., F.L.S., C.M.Z.S., "Telopea," Quorn Street, Sandy Bay.
- 1927 Lord, Graham, Vacuum Oil Company, Hobart.
- 1930 Lord, Colonel J. E. C., C.M.G., V.D., Police Department, Hobart.
- 1932 Lord, John, F.C.A. (Aust.), 41 Sandy Bay Road.
- 1928 McAulay, Professor A. L., Ph.D., The University, Hobart.
- 1927 Mace, Miss V. E., "The Pottery," Bothwell.
- 1927 Macfarlane, Charles, State High School, Hobart.
- 1923 Macfarlane, Mrs. C., 3 Montague Avenue, New Town.
- 1928 McElroy, J. D., 32 Bellevue Parade, New Town.
- 1930 McIntyre, J. A. L., Wentworth Street, South Hobart.
- 1922 Macleod, Mrs. L. H., 67 High Street, Sandy Bay.
- 1919 McKay, A. D., 26 High Street, Launceston.
- 1932 Manning, F. D., 48 Fitzroy Place, Hobart.
- 1918 Mansell, A. E., Bruny Island.



Year of  
Election.

- 1924 Marsh, James, Messrs. Cox, Kay Pty. Ltd., Collins Street, Hobart.
- 1918 Martin, Brigadier-General W., Launceston.
- 1931 Masters, W. E., Messrs. Tinning, Propsting, and Masters, Hobart.
- 1921 Masters, A. H., Forest Road, Trevallyn, Launceston.
- 1929 Mattingley, P. F. C., B.D.S., L.D.D., 36 Brisbane Street, Launceston.
- 1930 Maxwell, C. M., E.S. and A. Bank, Hobart.
- 1926 Meredith, David, Electrolytic Zinc Company, Risdon.
- 1927 Meredith, Mrs. David, 107 High Street, Sandy Bay.
- 1921 Meston, A. L., M.A., High School, Launceston.
- 1909 Millen, Senator J., "Roxburgh," Newstead, Tasmania.
- 1930 Mitchell, E. C., "Bayswater," Sandy Bay.
- 1907 Miller, R. O. M., 6 Main Road, New Town.
- 1911 Montgomery, R. B., 303 Davey Street, Hobart.
- 1927 Morris, J. M., The Union Bank, Hobart.
- 1918 Murdoch, Honourable T., M.L.C., 55 Montpelier Road, Hobart.
- 1929 Murray, J. F., Federal Taxation Department, Hobart.
- 1931 Murray, J., The Tasmanian Club, Macquarie Street, Hobart.
- 1921 Muschamp, Rev. E., Holy Trinity Rectory, Launceston.
- 1933 Nicholas, Miss Doris A., "Millbrook," Ouse.
- 1882 Nicholas, G. C., "Cawood," The Ouse, Tasmania.
- 1918 Nicholls, Sir Herbert, K.C.M.G., Pillinger Street, Sandy Bay.
- 1910 Nicholls, H. M., Department of Agriculture, Hobart.
- 1921 Nye, P. B., B.M.E., Mines Department, Hobart.
- 1932 Ockenden, D., Central Avenue, Moonah.
- 1921 Oldham, W. C., 39 George Street, Launceston.
- 1924 Oliver, H., Lindisfarne.
- 1931 Onslow, G. F., 270 Davey Street, Hobart.
- 1927 Orme, K., 76 York Street, Sandy Bay.

Year of  
Election.

- 1921 Overell, Miss L., Holebrook Place, Hobart.  
1921 Padman, R. S., 56 St. John Street, Launceston.  
1923 Parker, H. T., "Montana," Bellerive.  
1921 Patten, W. H., 59 Cameron Street, Launceston.  
1931 Patterson, Mrs. R. C., "Varuna," Holebrook Place,  
Hobart.  
1929 Pearce, Harold, Ellington Road, Lower Sandy Bay.  
1923 Pedder, A., "Sherborne," Upper Argyle Street,  
Hobart.  
1927 Penman, C. J., Smelting Works, Launceston.  
1930 Perkins, Mrs. C. H., 16 Turner Street, Fitzroy Place,  
Hobart.  
1902 Piesse, E. L., B.Sc., LL.B., "Merridale," Sackville  
Street, Kew, Melbourne.  
1910 Pillinger, J., 4 Fitzroy Crescent, Hobart.  
1926 Pitman, Professor E. J. G., B.A., B.Sc., The Univer-  
sity, Hobart.  
1925 Propsting, G. L., Earl Street, Sandy Bay.  
1931 Rait, W. L., B.Sc., 20 Fitzroy Place, Hobart.  
1927 Raymond-Barker, A. B., Darcy Street, Hobart.  
1930 Read, Mrs. Ronald, Wellwood Street, Lenah Valley.  
1929 Read, D. W., The University, Hobart.  
1932 Read, H. J., The Friends' School, Hobart.  
1932 Reeve, Rev. W. T., St. John's Rectory, Goulburn  
Street, Hobart.  
1931 Reid, Miss A. K., 338 Murray Street, Hobart.  
1921 Reid, A. McIntosh, 270 Davey Street, Hobart.  
1925 Reid, Miss M. L., The University, Hobart.  
1931 Rex, M., 7 Mona Street, Battery Point.  
1921 Rex, R. R., 7 Mona Street, Battery Point.  
1931 Reynolds, B. R., 176 Collins Street, Hobart.  
1928 Richardson, F. B., 60 Augusta Road, New Town.  
1925 Robinson, F. G., 83 Princes Street, Sandy Bay.  
1926 Robson, Mrs., Elphin Road, Launceston.  
1929 Roche, M. M., Lands' Titles Department, Hobart.

Year of  
Election.

- 1884 Rodway, L., C.M.G., The Botanical Gardens, Hobart.
- 1921 Rolph, W. B., "The Examiner" and "Courier" Office,  
Launceston.
- 1931 Ross, Hector, Cambridge, Tasmania.
- 1931 Rowlands, J. E. A., Public Trust Office, Hobart.
- 1922 Sargison, H., Elizabeth Street, Hobart.
- 1931 Scott, E., Queen Victoria Museum, Launceston.
- 1896 Scott, H. H., Queen Victoria Museum, Launceston.
- 1930 Scott, J. B., 5 Greenlands Avenue, Sandy Bay.
- 1928 Scott, R. A., Department of Agriculture, Hobart.
- 1896 Scott, R. G., M.B., 172 Macquarie Street, Hobart.
- 1921 Shields, Hon. Tasman, M.L.C., 13 Paterson Street,  
Launceston.
- 1925 Shoobridge, K., Glenora, Tasmania.
- 1921 Shoobridge, Hon. L. M., "Sunnyside," New Town.
- 1925 Shoobridge, Rupert, "Fenton Forest," Glenora.
- 1923 Shoobridge, S. E., Messrs. Oscar Smith & Co., Mac-  
quarie Street, Hobart.
- 1927 Shugg, A. W., M.B., B.S., 174 Macquarie Street,  
Hobart.
- 1923 Simson, Mrs. C. J., 3 St. George's Square, Launceston.
- 1932 Somerville, Miss J., Wellington Square School, Laun-  
ceston.
- 1932 Skemp, J. R., "Reediford," Myrtle Bank, Tasmania.
- 1927 Smith, Miss M., c/o The Countryman, 4 St. James'  
Buildings, 123 William Street, Melbourne, C1.
- 1921 Smithies, F., 34 Paterson Street, Launceston.
- 1925 Stackhouse, C. K. R., LL.B., 55 Paterson Street, Laun-  
ceston.
- 1930 Steane, S. W., Conservator of Forests, Hobart.
- 1928 Steele, R. B., Department of Agriculture, Hobart.
- 1929 Stephens, C. G., The University, Hobart.
- 1920 Swindells, A. W., c/o Messrs. Murdoch Bros., Market  
Place, Hobart.
- 1927 Tankard, L. W., Sheffield, Tasmania.
- 1918 Taylor, W. E., Elboden Street, Hobart.

Year of  
Election.

- 1931 Thwaites, J. B., Glenorchy.
- 1930 Travers, Miss C., Fisher's Avenue, Lower Sandy Bay.
- 1930 Travers, Miss I., "Nateby," Lower Sandy Bay.
- 1929 Thirkell, Major R. W., O.B.E., V.D., 405 Elizabeth Street, Hobart.
- 1929 Thomas, A. J. M., Short Street, The Glebe, Hobart.
- 1923 Thomas, J. F., Room 8, Wilga Chambers, 158 Philip Street, Sydney.
- 1922 Thompson, E. H., Lower Sandy Bay.
- 1931 Townley, D. G., 5 Waverley Avenue, New Town.
- 1928 Tribolet, D. R., Mount Stuart Road, Hobart.
- 1927 Turner, A. Jefferies, M.D., F.E.S., Wickham Terrace, Brisbane.
- 1928 Turner, J. W., Lt.-Colonel, V.D., Mona Street, Battery Point.
- 1923 Unwin, E. E., M.Sc., The Friends' School, Hobart.
- 1931 Usher, F., The Mercury Office, Hobart.
- 1930 Walch, Christine, M.B., Ch.M., 171 Macquarie Street, Hobart.
- 1927 Walch, J. H. B., M.B., 71 Crescent Road, Hobart.
- 1918 Walch, P. B. C., King Street, Sandy Bay.
- 1928 Walters, Rev. Walter, Scottsdale, Tasmania.
- 1931 Wallace, A. C., 140 Collins Street, Hobart.
- 1926 Ward, F. E., Director of Agriculture, Hobart.
- 1931 Waterworth, E., Poet's Road, Hobart.
- 1926 Waugh, E. C., LL.B., Waimea Avenue, Sandy Bay.
- 1922 Wayn, Miss A. L., c/o The Chief Secretary's Office, Hobart.
- 1930 Webster, E. H., "Greystanes," Red Chapel Road, Sandy Bay.
- 1927 Wells, F., Sandown, Lower Sandy Bay.
- 1929 White, G. L., The University, Hobart.
- 1926 Whittle, B. H., Augusta Road, New Town.
- 1925 Winch, M., c/o Brownell Bros. Ltd., Hobart.
- 1901 Wise, H. J., 13 Lord Street, Sandy Bay.
- 1927 Whishaw, R., M.B., Ch.M., Macquarie Street, Hobart.

# Annual Report

## 1932

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### *The Council and Officers.*

The Annual Meeting was held at the Society's Rooms, The Tasmanian Museum, Hobart, on 4th March, 1932.

The following were elected as Members of the Council for 1932:—Dr. A. H. Clarke, Mr. W. H. Clemes, Dr. W. L. Crowther, Mr. E. T. Emmett, Mr. V. V. Hickman, Dr. A. N. Lewis, Mr. L. Rodway, Mr. E. E. Unwin, Mr. F. E. Ward, and Mr. Clive Lord (*ex officio*).

The Council at its first meeting made the following appointments:—

Chairman of the Council: Mr. W. H. Clemes, B.A., B.Sc.

Secretary: Mr. Clive Lord.

Hon. Treasurer: Dr. A. N. Lewis.

Standing Committee: Messrs. Clemes, Lord, and Dr. Lewis.

Representatives of the Society on the Board of Trustees of the Tasmanian Museum and Botanical Gardens: Mr. W. H. Clemes, Dr. A. H. Clarke, Dr. W. L. Crowther, Dr. A. N. Lewis, Mr. E. T. Emmett, and Mr. E. E. Unwin.

### *Meetings.*

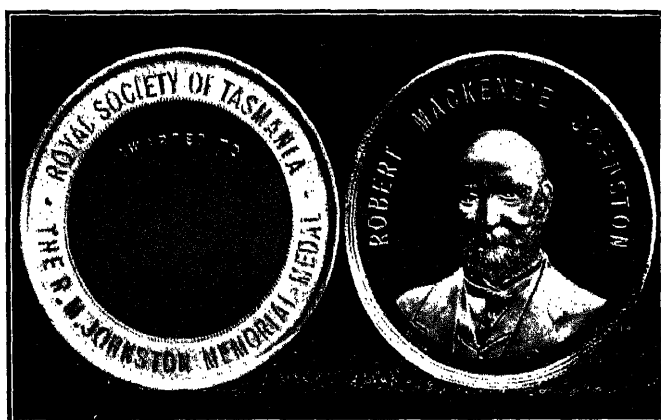
Ten meetings were held, and in addition to the lectures delivered, scientific papers of considerable interest and value were submitted.

(See abstract of meetings for titles of lectures, papers, &c.)

### *The Library.*

The Society's library continues to be of outstanding service, not only to members, but as a source of reference on scientific matters generally, and in this regard is an important factor in the general progress of the State. The removal to larger quarters has been of distinct advantage,

R. M. JOHNSTON MEMORIAL.



THE R. M. JOHNSTON MEMORIAL MEDAL.

LIST OF AWARDS:

- 1923 Sir J. W. Edgeworth David, K.B.E., C.M.G., F.R.S., F.G.S.  
1925 Professor F. Wood-Jones, M.B., B.S., M.R.C.S., L.R.C.P., D.Sc.  
1929 R. J. Tillyard, M.A., Sc.D. (Cantab.), D.Sc., F.R.S., F.N.Z. Inst.,  
F.L.S., &c.



but funds do not permit the cataloguing and binding to be kept as up to date as might be wished.

### *Natural Sciences.*

Reference was made in last year's report to the need for more attention being given to the natural sciences in Tasmania, and the fact that the Society had brought the matter under the notice of the Government.

The importance of the matter has been realised, and the Council is pleased to report that its efforts to have more attention paid to the natural sciences are bearing fruit.

### *The Botanical Gardens.*

The Council became concerned owing to certain criticisms made in regard to the policy of the Trustees of the Botanical Gardens, and in order to investigate the matter a special meeting of the Society was held in order to receive a report from the Society's representatives on the Trust, and an invitation was extended to the critics to attend. After a full discussion a resolution expressing confidence in the action of the Trustees was carried unanimously.

### *Finance.*

The financial position of the Society has been the cause of very considerable concern. The elimination of the Government grant, together with the reduction in the number of members consequent upon the general economic depression, has made the publication of the papers and proceedings a difficult matter. In view of the fact that the Library depends for its exchanges upon the publication of the papers and proceedings, and the work generally that the Society is doing on behalf of the State, the Council is approaching the Government with regard to the publication of the Papers and Proceedings for 1932.

The accounts, as published, should be read with the understanding that there are outstanding accounts amounting to approximately £125, including £100 owing on the printing of the 1931 papers and proceedings. This debt will be met out of 1933 subscriptions, but unless outside support is obtained it is difficult to know when the volume for 1932 will be published.\*

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\* Since the above report was compiled the Premier has kindly agreed to assist the Society by printing the 1932 volume.



The credits shown in the Memorial Fund are due to the fact that the purchase of books was held up during the currency of the Commonwealth Government's sales and primage tax. Now that this has been lifted education societies such as this are once more free to import books without excessive taxation being added to already high costs.

#### BRANCH AND SECTION REPORTS.

The Northern Branch carried on its usual operations during the year.

The only section of the Society which held regular meetings and discussion was the Education Section, which met regularly during the term under review.



THE ROYAL SOCIETY OF TASMANIA MEDAL.

LIST OF AWARDS:

1927 L. Rodway, C.M.G.

1930 Clive Lord, C.M.Z.S., F.L.S., F.R.A.I.A.

To face page 74.]



# THE ROYAL SOCIETY OF TASMANIA.

## GENERAL FUND.

### STATEMENT OF RECEIPTS AND EXPENDITURE, 1932.

RECEIPTS.		EXPENDITURE.	
	£ s. d.		£ s. d.
Balance brought forward	14 14 4	Salaries and wages	35 8 8
Subscriptions	187 19 0	Papers and proceedings—	
Rent of room	18 1 0	1930 (part)	£80 0 3
Sale of publications and reprints	17 14 2	1931 (part)	51 17 6
		General printing	131 17 9
		Library	20 2 2
		Northern Branch	20 11 10
		Light and fuel	8 8 0
		Insurance	8 8 6
		Miscellaneous	5 18 9
		Petty cash	4 10 2
		Bank charges	8 1 5
			0 0 3
		Carried forward (31.12.32)	238 6 10
			0 1 8
			£238 8 6

Examined and certified to be correct.

WALTER E. TAYLOR, F.F.I.A.,

Hon. Auditor.

23rd February, 1933.

A. N. LEWIS, Hon. Treasurer.

CLIVE E. LORD, Secretary.

11th January, 1933.

THE ROYAL SOCIETY OF TASMANIA.  
R. M. JOHNSTON FUND, 1932.

RECEIPTS.	£ s. d.	PAYMENTS.	£ s. d.
Balance brought forward (1.1.32) ....	0 18 6	Amount carried forward (31.12.32) ....	7 14 5
Interest received from Perpetual Trustee Co.	6 15 11		
	<u>£7 14 5</u>		<u>£7 14 5</u>

Examined and certified to be correct.

WALTER E. TAYLOR, F.F.I.A.,

Hon. Auditor.

23rd February, 1933.

A. N. LEWIS, Hon. Treasurer.

CLIVE E. LORD, Secretary.

11th January, 1933.

MORTON ALLPORT MEMORIAL FUND, 1932.

RECEIPTS.	£ s. d.	PAYMENTS.	£ s. d.
Balance brought forward (1.1.32) ....	4 19 9	Book for Library ....	0 12 6
Interest received from Perpetual Trustee Co.	6 15 8	Balance carried forward (31.12.32) ....	11 2 11
	<u>\$11 15 5</u>		<u>\$11 15 5</u>

Examined and certified to be correct.

WALTER E. TAYLOR, F.F.I.A.,

Hon. Auditor.

23rd February, 1933.

A. N. LEWIS, Hon. Treasurer.

CLIVE E. LORD, Secretary.

11th January, 1933.

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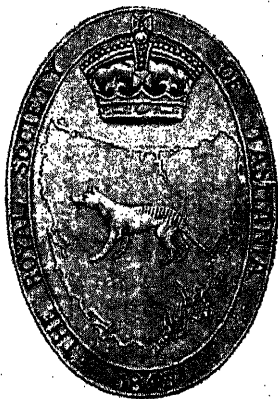
~~AGRICULTURE~~  
PAPERS & PROCEEDINGS

OF

# THE ROYAL SOCIETY OF TASMANIA

FOR THE YEAR

1933



(With 8 Plates and 8 Text Figures)

ISSUED 7TH JUNE, 1934

PUBLISHED BY THE SOCIETY

The Tasmanian Museum, Argyle Street, Hobart

1934

*Price: Five Shillings*



The responsibility for the statements and opinions in the following papers and discussions rests with the individual authors and speakers; the Society merely places them on record.

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Owing to financial exigencies, certain usual features of this volume have been omitted. It is hoped to remedy this in succeeding volumes.

# The Royal Society of Tasmania

## Papers and Proceedings, 1933

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# Papers of The Royal Society of Tasmania 1933

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## THE TROUT-FOOD INSECTS OF TASMANIA.

### PART I.—A STUDY OF THE GENOTYPE OF THE MAYFLY GENUS ATALOPHLEBIA AND ITS LIFE HISTORY.

By

R. J. TILLYARD, M.A., Sc.D. (Cantab.), D.Sc. (Sydney),  
F.R.S., F.N.Z. Inst., F.L.S., F.G.S., F.E.S.

Plates I. and II.

(Read 8th May, 1933.)

#### INTRODUCTION.

The study of the more important insects which serve as food for trout in any given country is, in these days of applied science, an indispensable preliminary to a full understanding of the methods by which a successful and permanent trout-fishery can be maintained in that country. For many years I have been interested in those groups of aquatic insects which are of most importance as trout-food. But I have never found, anywhere in Australia, any public realisation of their economic importance, and thus it comes about that, even to-day, when scientific ideas have penetrated further into the public mind than ever before, it still remains impossible for any work on such insects to be carried out officially. The alternatives are, either to leave the subject alone and let the knowledge gained die with one, or to work at the subject slowly in one's spare time, in the hope that something of value may come out of it in time to save the inland fisheries of Australia from deterioration due to lack of scientific knowledge.

It is my considered opinion that the time has now come when it is imperative that a scientific survey of the trout-food insects should be carried out in all the principal trout-fishing districts of the Commonwealth. These are to be found in New South Wales, Federal Capital Territory, Victoria,

and Tasmania. From a faunal point of view, the first three are closely united, and might well be studied as a single unit, though the number and variety of the streams included would make a thorough survey a lengthy and difficult task. Tasmania, however, needs to be studied separately, not only because it is an island, possessing marked peculiarities in its aquatic fauna, but also because, in Tasmania alone, of any part of the Commonwealth, there are present fresh-water lakes suitable for trout-fishing and, in many ways, superior to the rivers.

The present paper is planned to be the first of a series to be written for the Royal Society of Tasmania, dealing with the Trout-food Insects of that State. As the Order Plectoptera, or Mayflies, is the most important order of insects considered as trout-food, I propose to deal with them first, leaving the other aquatic orders for later treatment.

When one comes to study the Mayflies of Tasmania, one is met with the remarkable fact that only two species have so far been described from that island, and that one of these has not been recognised since it was last dealt with by Eaton (1884), nor does it appear ever to have been collected again since its original capture by Dr. Hooker in 1842! As this species was designated as the genotype of the genus *Atalophlebia* (Eaton), by that author, and as that genus contains the great majority of Mayflies found, not only in Tasmania, but also throughout Australia, it will readily be agreed that the first step in our study should be a thorough examination of this species and its life-history. This is the purpose of the present paper.

#### THE GENOTYPE OF THE GENUS ATALOPHLEBIA

(*Atalophlebia australis*, Walker).

The genus *Atalophlebia* was proposed by Eaton in 1881, the genotype being designated as *Ephemera australis* (Walker), from Tasmania. In this genus Eaton (1884) included a number of species from Ceylon, Australia, New Zealand, Japan, South Africa, and South America. Most of these had been previously placed by him (1881) in the genus *Leptophlebia*, Wwd., Series 1.

Walker's original description (1853) devotes only a few lines each to the male imago and the subimago, the latter being queried as possibly not belonging to the same species. His descriptions deal only with colour and measurements, and hence it is not possible to determine the species with

certainly from his descriptions, but only from an examination of the actual type series. There are, however, two outstanding colour-characters in the description, viz., that the abdomen of the male imago is red (an unusual character for this genus), and that the forewings of the subimago have the black veins clouded with brown, and show "two broad, irregular, interrupted and very oblique bands." Eaton, when re-examining the type-series, made it clear that Walker intended by these latter remarks to indicate a clear space as distinct from the general shaded condition of the wing, and he describes this space as "a lambda-shaped space free of cross-veinlets and colouring, the long stroke of the latter being represented by a narrow clearing describing a gentle curve from the apex to the anal angle of the wing, and the short stroke by another narrow clearing running out from the midst of the wing-roots to the former." He adds that in some specimens the long and short strokes of the letter are separated by a little colouring.

During a recent visit to Tasmania I set myself the task of trying to solve, in my spare time, the problem of what this species really was. Arguing that Dr. Hooker probably collected either near Launceston, or near Hobart, or on one of the rivers crossed by the road connecting the two cities, I tried first the South Esk and Macquarie Rivers. I learnt from my friend Mr. Eric Hudson, of Launceston, a keen angler, that there was a rise of large Mayfly on the Macquarie River known as the "red spinner." This species was most abundant in November and December, and my visit was in February. However, at our first visit to the river, in spite of inclement weather, we succeeded in securing two female imagos and a subimago of a species which agreed closely with the descriptions given by Walker and Eaton. Later still, the same species was found commonly on Lake Leake. The nymphs were found abundantly under stones and rocks near the edge of the lake. Subimagos were reared from nymphs and imagos from subimagos, so that the specific identity of all the stages has been assured.

The next step was to gather information about the original type series, and also to have the new specimens compared with that series. I therefore wrote to Mr. D. C. Kimmins, of the British Museum, and sent him examples of the male imago in spirit. In his reply Mr. Kimmins states:

"Neither Walker nor Eaton actually fixed the type of the species. I am able, however, to recognise the imaginal example from which Eaton made his

figures for his 1871 paper, and, as far as I can tell, the other three imagines belong to the same species. . . . None of Walker's imagines have more than two tail-filaments, but Eaton quotes two measurements, so there were probably three."

Mr. Kimmins very kindly sent drawings of the hindwing and of a KOH preparation of the male genitalia, prepared from one of the examples of the type series of imago. From these, I am able to state with certainty that the species taken on the Macquarie River and on Lake Leake, and known to anglers as the "red spinner," is the true *Atalophlebia australis* (Walker). It now remains to redefine the genus in the light of modern knowledge, to indicate the characters in which it differs from related genera, and to describe and figure the various stages of the type species. I suggest that Tasmanian anglers should adopt the name "Large Red Spinner" for the imago (both sexes), and the very distinctive name "Lambda Dun" for the subimago (both sexes).

#### Family LEPTOPHLEBIIDÆ.

##### Genus *Atalophlebia* Eaton, 1881.

*Imago*.—*Forewing* well supplied with cross-veins, including a complete, or nearly complete, set in the costal space. Along distal margin of wing there are no isolated veinlets, but each longitudinal vein ends either simply or with a short, curved posterior branch. CuP always strongly and more or less sigmoidally curved. *Hindwing* with the costal margin strongly arched before half-way, but never angulated, then bending down so as either to approach very close to Sc for some distance, or even to fuse with it. Sc also arched, but not so strongly. R<sub>1</sub> straight. *Legs*: In the elongated forelegs of the male, tibia and tarsus are each about half as long again as femur; first segment of tarsus very short and closely attached to end of tibia, the other tarsal segments long and slender, 2 and 3 both longer than 4, 5 shortest. Middle and hind tarsi in male and all tarsi in female shorter than tibia, and appearing only four-segmented owing to fusion of first segment with tibia; comparative lengths of segments variable for different species. Tarsal claws alike, or nearly alike, narrow, hooked at tip, and carrying a transparent flange. *Genitalia of male*: Limbs of the forceps three-segmented, the basal segment very long, the other two very short. Penis variable, more or less

deeply bilobed. *Caudal filaments* variable, some species having three, some two, and some being variable (including the genotype); cerci always very long, especially in the males.

*Subimago*.—Differs from imago chiefly in its opaque wings and shorter caudal filaments, of which there are usually three, rarely only two. In most species the subimaginal stage lasts for a considerable time, from one to nearly three days, but in some cases less.

*Nymph*.—Of the crawling type, found clinging to submerged rocks, stones, or logs; more or less flattened, capable of running quickly. *Head* fairly large, with eyes placed laterally, antennæ longer than width of head. *Labrum* more or less excavated in middle of free border. *Mandibles* with outer margins strongly curved, with two well-developed incisors; protheca present. *Hypopharynx* lobed, paragnaths strongly curved and spreading. *Maxillæ* with three-segmented palp and apically truncate inner lobe. *Labium* with three-segmented palps, broad paraglossæ and much smaller and narrower glossæ. *Legs* strong and stout, the femora rather broad, flattened, the tibia and tarsus slenderer, also flattened; *tarsal claws* denticulate. *Gills* seven pairs, on abdominal segments 1-7; each gill double, of very variable form. *Caudal filaments* three, the cerci long and stout, the appendix dorsalis usually well developed, but some times much weaker than the cerci.

*Genotype*.—*Atalophlebia australis* (Walker), from Tasmania. The curious form of the arched costa of the hindwing serves to distinguish this genus from all the others given by Eaton (1884). In the absence of any detailed knowledge of the genotype of *Atalophlebia*, it was, perhaps, unwise for later authors to have attempted the subdivision of this genus. Barnard (1932) separated off the South African species as a new genus, *Aprionyx*, on the character of the nymph possessing smooth tarsal claws. He did not know what the tarsal claws of the nymph of the genotype of *Atalophlebia* were like, since that nymph was then unknown. However, he argued that the Australian species were most likely to be similar to the New Zealand ones, which were known to have nymphs with denticulate tarsal claws!

Now that the nymph is discovered, it turns out that Barnard's surmise is correct. In most other respects, *Aprionyx* is very closely related to *Atalophlebia*. In imaginal characters, the only important difference that I can indicate is in the form of the penis, which is not bilobed as in *Atalo-*



*phlebia*, but either simple or, at most, notched at the tip. *Aprionyx* agrees with *Atalophlebia* in such important characters as the general venational scheme, including the shape of the arched costa in hindwing, in the form of the tarsal claws and genital forceps; also, amongst nymphal characters, in the general form of the antennæ and mouth-parts, notably in the broad truncated end of the inner lobe of the maxilla and the short distal segment of the palp, in the general form of the mandibles, hypopharynx and labium, though the latter has a much shorter distal segment on the palp in *Aprionyx*. The general form of the nymphs is much the same. If *Aprionyx* is to be accepted as a valid genus, it must be recognised that it is nevertheless extremely closely related to *Atalophlebia*.

Of the Chilean genus *Atalonella*, N. and M. (1924), I am unable to speak with certainty; but it appears to be distinguished from *Atalophlebia* by very slender characters. I do not regard the oblique pterostigmatic veinlets as a good generic character, since both oblique and nearly transverse types are found within the Australian species of *Atalophlebia*. *Atalonella* resembles *Atalophlebia* in the form of the penis, in having the tarsal claws of the nymph denticulate, and in other important characters. The chief distinguishing characters are to be found in the costal series of cross-veins being incomplete basally and in the different form of the hindwings.

What is really needed is a comprehensive monograph of all the forms originally included in the genus *Atalophlebia* (Eaton), with special attention to the differences exhibited by adults and nymphs in the different zoogeographical regions represented. The present paper is intended not only to clear up the situation as regards the genotype, but also to assist in laying the foundations for such a study, including a study of the abundant Australian and Tasmanian fauna.

#### ATALOPHLEBIA AUSTRALIS (Walker).

(Plate I., Figs. A and B; Plate II., Figs. 1-20.)

♂ *Imago* (Plate I., Fig. A).—*Total length* of body (dried), 8 to 11 mm.; *abdomen*, 5 to 7 mm. *Forewing*, 9.5 to 12 mm.

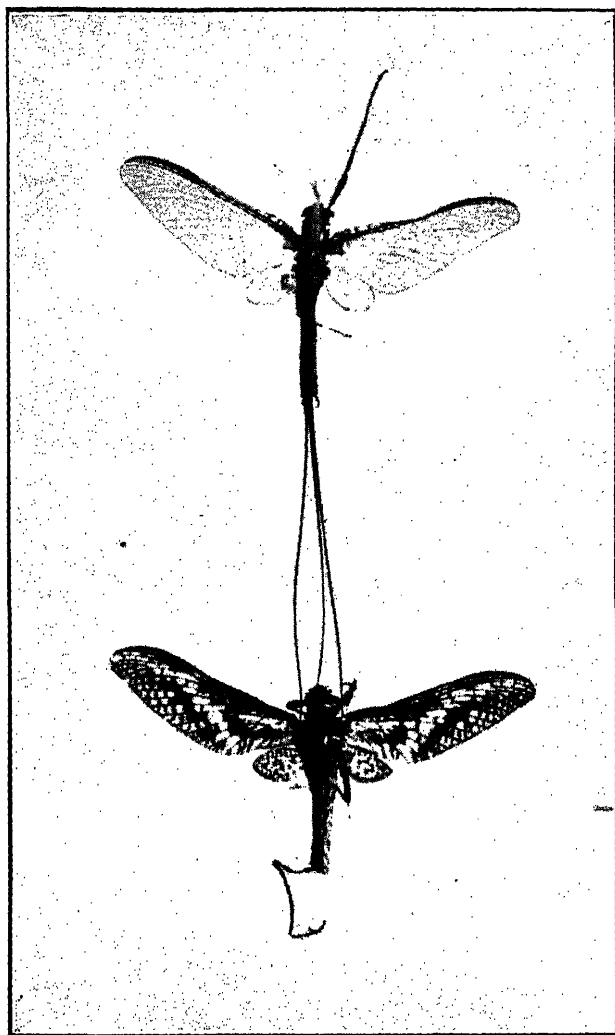
*Head*.—General colour black, with a touch of reddish-brown on the occiput; *antennæ* very short, dark brownish; *compound eyes*, with the large inner division brownish-grey, the smaller outer division grey; *ocelli* greyish-white; parts around the mouth reddish-brown.

*Thorax*.—Shining black above, with two small, reddish-brown spots near posterior angle of mesonotum. Sides mottled in black and reddish-brown, with two very irregular patches of whitish, one close to the base of each wing, the white in each case more or less surrounding a dark brownish patch extending obliquely away from the wing-base. *Legs*: Forelegs (Fig. 4) 7-9 mm. long, blackish, tinged with brown at base of femora and on tarsi; tibia about equal to tarsus in length, and each of these half as long again as femur; comparative lengths of tarsal segments, in descending order, 2, 3, 4, 5, 1; middle and hind legs (Fig. 5) about 5 mm. long, reddish-brown; comparative lengths of the four visible segments (omitting 1), in descending order, 5, 2, 4, 3. *Tarsal claws* (Fig. 6) rather long, slender, similar, terminally hooked, and each carrying ventrally a transparent flange extending apically as far as base of hook, where it is strongly angulated.

*Wings*.—*Forewing* (Fig. 1) subtriangular, with tornus at about two-sevenths of wing-length. Costa nearly straight from brace to pterostigma, carrying a complete series of costal veinlets, 7 to 10 in number up to the bulla; pterostigma beginning not far distant from bulla, and carrying a large number of oblique veinlets, some simple, some distally forked, and a few connected by cross-struts. General colour of all veins reddish-brown, a part of C, R<sub>1</sub>, and MA somewhat darker than the rest. Wing-membrane mostly hyaline, but base of wing up to brace suffused with yellowish-brown, and the costal and subcostal spaces appearing throughout also more or less suffused with pale reddish-brown owing to suffusion of the cross-veins in these areas; this suffusion is most marked in the pterostigma and on the whole of the cross-veins of the subcostal space; in particular, there is a dark suffused patch around the cross-vein below the bulla, and a much larger suffused patch for two cellules below the beginning of the pterostigma. The cross-venation is sparse between the branches of R<sub>s</sub>, except distally, and also basally between the branches of MA, MP, and CuA. *Hindwing* (Figs. 2, 3) 2 to 3 mm. long, the costal margin strongly curved to about half-way, where it bends downwards so as almost to meet Sc, and then runs very close above it, finally meeting it at about four-fifths of the wing-length. Most of the broad portion of the costal space is devoid of cross-veins, but there are two or three present just as it begins to narrow, and usually several more in the extremely narrow part. In some of the specimens, particularly those of smaller

size, the costa meets Sc more quickly, at about two-thirds of the wing-length, and thus the narrowed portion of the costal space is much shortened (Fig. 3). Sc is evenly arched upwards from base to where it approximates to costa; thence onward it is nearly straight.  $R_1$  is usually straight, forming, as Eaton put it, "the chord of the arc" above it. A complete series of cross-veins exists between Sc and  $R_1$ , but the individual cross-veins are variable in position in different specimens.  $R_s$  is secondarily attached to MA, with or without a free piece of the original stem remaining basally; it carries a single triad. MA is either simple or with only a single terminal posterior branchlet. MP has a well-developed triad arising before half-way and usually a short terminal branchlet on MP<sub>1</sub>. Both CuA and CuP are fairly straight veins with well-developed terminal branchlets. 1A is a simple, curved vein. The wing is very broad in the middle, about two-thirds as wide as long, but distinctly narrow basally, the posterior margin from base to end of 1A being almost straight.

*Abdomen*.—Seg. 1 short, broad, blackish, closely attached to thorax; 2 short; from 3 to 7 the segments become progressively longer and somewhat narrower; 8 as long as 7, broadening slightly distally; 9 two-thirds as long as 8, slightly angulated or spined postero-laterally; 10 considerably shorter and a little narrower than 9. Segs. 2-10 generally deep reddish in colour, 2-3 slightly tinged with reddish-black above and on sides, 4-8 on sides only, 9-10 slightly darkened; some indication generally of a paler transverse band along posterior margin of 2-7, and in some specimens also of a paler mid-longitudinal line. *Genitalia* as in Figs. 7-8, the forceps-basis rather short and broad, slightly notched in middle of posterior border; forceps three-segmented, the first segment fairly broad basally, very long, the distal half of the inner margin somewhat narrowed or excavate; second and third segments very short, subequal in length, suboval in shape, the two taken together only about one-sixth the length of the basal segment. Penis broad at base, tapering distally by its sigmoidally curved sides to two diverging apical lobes separated by a deep subtriangular cleft; each apical lobe bears ventrally a curious structure which appears to be a sac or pocket of delicate chitin, the two pockets being just in contact on the middle line. Viewed in profile (Fig. 8) the penis is nearly straight, a little inclined upwards distally and narrowed for its distal third; the pockets can be clearly seen just projecting ventrally. In some specimens



*ATALOPHLEBIA AUSTRALIS*. (Walk.)

Imago and Subimago—Enlarged.



the median cleft does not reach as far as the pockets, in others it appears to pass well down below them. *Cerci* stout, 17-25 mm. long, blackish with reddish-brown tips; *appendix dorsalis* extremely variable, being entirely absent in some specimens, short and slender in others (from one-third to one-half as long as cerci), and, in others again, almost as long, though not as stout as the cerci; colour blackish.

♀ *Imago*.—Differs from the male in being of somewhat stouter build and often of darker colouration; the reddish-brown shading along the costal margin of forewing is more pronounced. Forelegs shorter than in male, 5 to 6.5 mm., tarsus with only four distinct segments, 1 being fused with tibia; comparative lengths of segments, in descending order, 5, 2, 3, 4; colour blackish. *Subgenital plate* entire; *subanal plate* deeply, almost semi-circularly, excised (Fig. 9). *Cerci* generally somewhat shorter than in male, 15 to 20 mm. long; *appendix dorsalis* equally as variable as in male.

*Subimago* (both sexes) (Plate I., Fig. B).—General appearance when freshly emerged, black, with the pattern of the folded wings blackish and very prominent. In the dried specimen, the body-colouring becomes black tinged with greyish, and the shaded areas of the wings dark fuscous, with a slight indication of brown along the costa. The general pattern of the forewings is brought about by the irregular placing of the cross-veins and their being more or less shaded with blackish. This pattern may best be described as a general rather mottled dark ground colour, with a hyaline space in the form of a Greek letter *lambda* or an inverted uncial Y. The long stroke of the *lambda* begins at the apex, and runs with a gentle curve concave to the outer margin, so as to end at a point a little beyond the tornus; the short stroke runs from the wing-base between MP and CuA, and usually, but not always, fails to meet the long stroke at about its lower third owing to the presence of two clouded cross-veins, one between MP<sub>1</sub> and MP<sub>2</sub>, the other between MP<sub>2</sub> and CuA. The heaviest shading occurs along the margins of the *lambda*-mark, along the whole of the costa except near its middle, over the whole of the pterostigma and also below its middle portion. In the hindwing, all the cross-veins and terminal branchlets are heavily shaded. *Legs* blackish, with a touch of brown on femora. *Caudal filaments* much shorter and more weakly developed than in imago, greyish-brown.

*Nymph* (Figs. 10-20).—*Total length* (excluding tail-filaments), 9 to 11.5 mm. *Cerci*, 10 to 14 mm.; *appendix dorsalis* generally slightly shorter.

General form subcylindrical, broadest across mesothorax. the thorax and abdomen convex above, flattened beneath. General colour a rich brown. *Head* about as long as wide, broadest across the eyes, which are black and situated postero-laterally; in front of the eyes runs a pale transverse line indicating the suture between epicranium and frons; ocelli blackish, the two lateral ones set just behind the suture, in line with the anterior angle of the eyes; the median one well forward. *Antennæ* about half as long again as the head, very slender, pale semi-transparent brownish-yellow, set wide apart and just forward of the median ocellus. *Clypeus* and *labrum* much narrower than frons, the outer contour of the head laterally being completed by the broadly rounded outlines of the mandibles.

*Mouth-parts.*—*Labrum* (Fig. 13) about twice as wide as long, its lateral borders well rounded, with short hairs, middle portion of anterior border hollowed out, the sides of the hollow weakly crenulate; surface generally hairy, there being two sets of short, dense hairs arranged transversely, one on either side of the middle line, and two slightly curved rows of closely set sockets carrying longitudinally directed hairs, one row curving around the median incision of the free border, and a shorter row further basad, crossing the two sets of transverse hairs. *Mandibles* (Fig. 14) strong and stout, with very curved outer margins; incisors large and separate, each subdivided apically into two or more separate teeth; *prostheca* inserted close to inner incisor and consisting of a slender process, shorter than the incisor, smooth in the right mandible and apically crenulate in the left, together with a brush of hairs about twice as long (Fig. 15); molar areas with a grid formed of about a dozen transverse ridges or laminae, each fringed with minute, delicate hairs closely set; in the right mandible, the molar area ends in a very acute process, the two mandibles working together very asymmetrically. *Hypopharynx* (Fig. 16) very complex, consisting of a divided median lobe fairly strongly chitinised around the edges, and two slenderer, pointed processes of very thin, transparent chitin, longer than the median lobes: *paragnaths* large, transverse, strongly curved backwards, the anterior border with a complete fringe of hairs. *Maxillæ* (Fig. 17) with three-segmented palp, the basal segment subcylindrical, smooth, the middle segment narrowed basally, longer than the basal segment, and carrying a series of stiff setæ on the inner surface and scattered soft hair along the outer margin, the distal segment very

short, about half as long as the middle segment, and with plentiful soft hairs on its outer margin to tip; inner lobe broad and truncate, with a dense brush of curved hairs along the whole of its outer margin. *Labium* (Fig. 18) with three-segmented palp, the basal segment transverse, broad, the middle segment narrowed basally, not so wide, about as long as the basal one; the distal segment cornute, with short, stiff setæ along inner margin and a row of about six longer ones placed longitudinally on outer surface; glossæ small, close together, standing out almost at right-angles to the rest, and resembling the soles of a pair of feet standing together; in Fig. 18 they are shown as pressed down on a slide with cover-slip; paraglossæ large and broad, the outer margins strongly curved and very hairy, the inner margins forming almost a right angle with them, straight and almost touching the glossæ; distal half of surface very hairy.

*Thorax* strongly built, convex but not humped. *Prothorax* well developed, about as wide as head, less than half as long as wide, the anterior margin concave, the posterior straight, the lateral margins produced into a narrow, curved, transparent flange; colour dark-brown, with a pale mid-longitudinal line. *Pterothorax* (combined meso and meta-thorax) generally dark-brown, slightly mottled with paler patches, and having a pair of rather indistinct dark blotches near antero-lateral angles; the pale mid-longitudinal line of the pronotum is continued very faintly backwards for some distance on the mesonotum; wing-sheaths broad, reaching to end of third abdominal segment, dark brownish. *Legs* (Fig. 11) subequal, the middle pair slightly shorter than the other two, the fore pair with the femora slightly broader and tibiae slightly longer than the others; femora broad, flattened, armed with numerous short, stiff setæ; tibiae narrow, cylindrical, somewhat flattened, a little longer than femora in forelegs, a little shorter in the other two pairs, inner margin armed with fine hairs and setæ; tarsi about half as long as tibiae, flattened cylindrical, slightly narrower, inner margin armed with short setæ; *tarsal claw* (Fig. 19) well developed, about half as long as tarsus, strongly hooked at apex, and carrying a series of fine denticles along its inner margin. Colour medium brown, banded with darker brown, as follows:—Femora with three bands, an indistinct one near base, and two fairly well defined bands, one across middle and one near apex; tibia with a rather narrow basal band and a



broader band covering about the first two-thirds of the distal half; tarsus with a broad band covering a little more than the basal half.

*Abdomen* convex above, flattened beneath, tapering gradually from base to apex; the segments lengthening from 1 to 8, but 8 only slightly longer than 7; 9 markedly shorter than 8 and slightly narrower; 10 much shorter and narrower than 9. Segment 1 has no lateral flange, and its postero-lateral angles are almost right-angles; segments 2 to 9 carry lateral flanges produced postero-laterally into sharp, backwardly directed spines; the spines of segment 2 are the smallest, those of succeeding segments becoming larger up to segments 7 and 8, that of segment 9 smaller again; segment 10 has the postero-lateral angles slightly prominent, rounded. Colour of abdomen dark-brown, with a pale, whitish, subtriangular spot covering the middle of each suture from 1-2 to 8-9; a pair of small, oval, pale-brown spots placed antero-laterally on segments 2-9, the dark-brown surrounding them running out on to the flange beyond them; less distinct but larger pale areas are indicated postero-laterally but closer together, but these are only at all well indicated on segments 4 to 9; segment 10 darkest at sides and posteriorly. On the flanges of segments 2 to 7 there is an oblique blackish patch near the insertion of each gill; tips of all lateral spines slightly darkened. *Gills* (Fig. 20) seven pairs, each gill consisting of a pair of lamellæ prolonged into three slender, pointed, digitate processes; the outer and upper lamella is somewhat narrower than the inner and lower, and has a stout tracheal trunk which gives off short weak branches basally followed by strong branches into each of the three digitate processes; the inner and lower lamella is broadened on one side, and the three trachæ running into the processes arise separately from near the base of the lamella. In the natural position, the upper lamella partly conceals the lower; in Fig. 20 they have been separated to show their full outlines. The largest gills are on segments 2 to 5, those of segments 1 and 6 are smaller, about equal; those of segment 7 the smallest and shortest of all.

*Types*.—In reply to a letter inquiring about the type series in the British Museum, Mr. D. E. Kimmins has very kindly supplied the following information:—"As the type of the species has not been fixed, I would suggest that you designate the imago figured by Eaton as the type (it is the most complete)." This course would seem to be a wise one,

and I therefore adopt it here, designating the specimen indicated by Mr. Kimmins as the *holotype* male imago of the species. The remaining male imagos thus become paratypes. A female imago from my own collection is designated as the allotype.

The problem of the subimago described by Walker is not so easy, since it will be remembered that he attached a query to the word in his description, thereby indicating his doubt as to whether it really belonged to this species. It appears, therefore, wiser to make quite certain by designating a good specimen of the subimago from my own collection as type subimago, and a specimen of the nymph, also from my own collection, as type nymph. In order that these may all be readily accessible to students, they are being presented to the British Museum Collection.

*Localities.*—Macquarie River and Lake Leake, Tasmania (February, 1933). The specimens taken on the Macquarie River are generally somewhat smaller than those from the lake, where the conditions are exceptionally favourable for the nymphs.

*Habits.*—The nymphs are found under logs, rocks, or stones submerged in the water, either along the edge of the river or close to the shore of the lake. It evidently feeds on humus and decayed vegetable matter. On opening the mouth of a captured nymph, it will be found to be full of minute particles of vegetable material brushed off and collected by the action of the mandibles and maxillæ. The nymph is a sluggish creature, but can run fairly quickly when attempting to escape.

The few subimagos captured were all taken on cold, windy days, either clinging to reed-stems near the margin of the river, or resting on the ground some way back from the lake, during a strong gale. The lambda-pattern of the wings is very conspicuous in the resting position, and makes this subimago comparatively easy to recognise, though those of certain other as yet undescribed Tasmanian species approach it fairly closely.

The imagos were taken, in the case of the Macquarie River specimens, either drowned and floating on the water, or by rearing from subimagos. At Lake Leake, in spite of the high wind, they were caught flying strongly against the wind, along the shore of the lake. Every time the wind

abated slightly, the Mayflies would be on the wing at once, buffeted about as they were, until compelled again to take shelter by resting on the ground, or on rocks or the trunks of near-by trees.

#### VALUE AS TROUT-FOOD.

Mr. E. Hudson informs me that there is a big rise of this Mayfly on the Macquarie River in November and December, and that the trout feed on it readily. Observations are required concerning the method of disclosure of the subimago from the nymphal skin; especially whether any considerable number of nymphs emerge quite close to the banks, or whether most of them rise well out into the stream, so that the floating subimago or "lambda dun" becomes an attractive bait for the rising trout while it is drifting towards the shore. Further observations should also be made to determine the dates of the first and last appearances of this Mayfly during the season. It is known already that it lasts from November to the end of February, and it evidently constitutes one of the most important articles of food for trout in the Macquarie River.

As regards Lake Leake, I was not able to go out on the lake and dredge the bottom for nymphs, nor did I see any rise of the Mayfly during the hour or so that I was there. All the nymphs that I found were clustered on the undersides of submerged stones, rocks, and logs along the edges of the lake; in these places they were very abundant, twelve full-grown nymphs being taken from beneath one small submerged stone. The value of the species to anglers on the lake depends largely on how frequently the nymphs rise to the surface well out from the shore, so that the "lambda duns" have to drift on the surface of the lake before reaching shelter, and also on whether or not the imagos or "large red spinners" do normally, in bright sunny weather, fly over the lake in such a way as to attract the trout to rise at them.

It would manifestly be unwise to disturb the balance of nature on Lake Leake by the introduction of other species of Mayflies until such time as the above observations have been carefully made. Further, a complete survey of the Mayfly fauna of the lake is required, including the life-histories and distribution throughout Tasmania of the species found there. When that has been done, the value of such an experiment as the introduction of the nymphs of

the "Penstock Brown" or other species of Mayfly can be scientifically calculated, and it may well be that such introductions may then be shown to be desirable for the improvement of the trout-fishing.

In the meanwhile, I think that the supply of this Mayfly in the Macquarie River could be augmented, or at any rate prevented from dropping, by a judicious use of more or less decayed timber, such as rotten logs. When old willows or gum-trees are cleared away near the river, they might be cut into convenient lengths, and placed in various parts of the river in such a way that they are not likely to become snags for the anglers. The Mayfly nymphs will find their way to these logs in large numbers, and, hiding in their cracks and crannies, proceed to obtain a rich living from the vegetable material which collects on them and from the products of their decay. In Lake Leake there would appear to be already a plentiful supply of decaying wood, since part of the area submerged to form this lake was originally forest. This is probably one of the chief reasons for the abundance and large size of *Atalophlebia australis* on this artificial sheet of water.

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## LEGENDS OF FIGURES, PLATE II.

FIGS. 1-9. *Atalophlebia australis* (Walk.).

## Imago, parts.

FIG. 1. Forewing, with New Notation of Venation.  $A_1, A_2, A_3$ , the three convex anal veins.  $IA$  the interpolated concave anal vein;  $CuA$ , anterior cubitus, convex;  $CuP$ , posterior cubitus, concave;  $MA$ , anterior median, convex;  $MA_1, MA_2$ , its branches;  $IMA$ , interpolated concave sector of triad;  $MP$ , posterior median, concave;  $MP_1, MP_2$ , its branches;  $IMP$ , interpolated convex sector of triad;  $pt$  pterostigma;  $R_1$ , radius;  $Rs$ , radial sector;  $R_2$  to  $R_{4+5}$  its branches;  $IR_2, IR_{2a}, IR_{3a}$ , interpolated convex sectors of triads;  $Sc$ , subcosta ( $\times 10$ ).

FIG. 2. Hindwing of same specimen as Fig. 1, enlarged twice as much ( $\times 20$ ). Lettering as in Fig. 1.

FIG. 3. Hindwing of holotype male, from drawing sent by Mr. D. O. Kimmins.

FIG. 4. Tarsus of foreleg of male ( $\times 20$ ), with portion of tibia.

FIG. 5. Tarsus of hindleg of male ( $\times 20$ ), with portion of tibia.

FIG. 6. Tarsal claws from hindleg of male ( $\times 100$ ).

FIG. 7. Genitalia of male, dorsal view after removal of tenth tergite and appendages ( $\times 50$ ).  $gp$  lateral gonapophysis or forceps-basis;  $pe$  penis;  $st$  gonostyle.

FIG. 8. The same, viewed laterally. Lettering as in Fig. 7.

FIG. 9. Subanal plate of female imago ( $\times 40$ ).

FIGS. 10-12. *Atalophlebia australis* (Walk.).

## Nymph and parts.

FIG. 10. Nymph ( $\times 10$ ). Colour-pattern omitted except on abdominal segments 5-8; gills only represented on left side, so as to show shape of abdominal segments on right; caudal filaments cut short.

FIG. 11. Middle leg ( $\times 32$ ).

FIG. 12. Basal segments of cercus ( $\times 100$ ).

FIGS. 13-20. *Atalophlebia australis* (Walk.).

## Parts of nymph.

FIG. 13. Labrum ( $\times 50$ ).

FIG. 14. Mandibles, dorsal view ( $\times 50$ ).

FIG. 15. Prosthoea of left mandible ( $\times 100$ ).

FIG. 16. Hypopharynx and paragnaths ( $\times 50$ ).

FIG. 17. Maxilla ( $\times 50$ ).

FIG. 18. Labium ( $\times 50$ ).

FIG. 19. Tarsal claw ( $\times 100$ ).

FIG. 20. Pair of gills from second segment of abdomen, with the two lamellæ well separated to show their complete forms; the outer and upper lamina above the inner and lower lamina below ( $\times 30$ ).





NOTES ON A FOSSIL PINE FROM THE PERMO-CARBONIFEROUS STRATA (*DADOXYLON PENMANI*, SP. NOV.).

By

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Curator, Queen Victoria Museum and Art Gallery,  
Launceston.

(Read 24th July, 1933.)

GENERAL NOTES.

The fossil came from the air-shaft of the Aberfoyle Mine, and its age was determined by the Government Geologist (Mr. P. B. Nye) as being Permo-Carboniferous. This field note is of some importance, since of recent years the old genus *Dadoxylon* has been revived to meet the case of all such Australian Palæozoic specimens as are duly segregated from the more ancient type of *Cordaite*s. In the same connection the genus *Araucarioxylon* is now restricted to Mesozoic pines, of more or less Araucarian habit. Such being the case, our fossil must therefore be either a true survival of the Devonian *Cordaite*s, or else the more recently evolved *Dadoxylon*.

In his "Prodromus of the Palæontology of Victoria" Sir Frederick McCoy says that *Cordaite australis* has no medullary rays, but retains the older structure of scalariform ducts. As the present specimen *has medullary rays*—although, curiously enough, quite absent from many chipped specimens of the wood—and *no ladder ducts*, it seems correct to classify it as a *Dadoxylon*. In the item of a species, I have called it "*Penmani*," after Mr. C. J. Penman, who secured the fossil for us.

Appended is a detailed account of the microscopical structure of the three faces of the wood.

TRANSVERSE.

It is impossible, with the imperfect state of preservation, to obtain a series of zonal growths, but from microscopical specimens the following can be determined:—

The tracheids are thick-walled, and both quadrangular and circular (or an approach to it); the wood has been



badly compressed during preservation, so much so that the autumnal wood zone has been driven out of alignment. No evidence of any value can be collected from this aspect of the wood respecting the medullary rays *in the majority of instances*; indeed, it was at first regarded as useless to expect any; but a fortunate scrap came to light in which the structure was good enough to determine the following facts:—

The rays may be very narrow, and apparently only a single tier wide, or two or three tiers in structure, the wider ones showing most commonly in the autumnal wood; possibly distortion may here accentuate appearances to some extent.

Some, beyond all doubt, grow wider in the autumnal zone, and can be traced throughout their course.

#### RADIAL.

As might be expected from the transverse structure of the wood, the radial aspect depicts an even grain, and by measurement it was found that an average tracheid was 1-500th of an inch wide, as against the 1-438th of an inch for *Araucaria cunninghami*, while *Agathis* was slightly coarser. Fractured specimens showed that quite a number of pieces could be found without any medullary rays at all, and in making a duplicate study set much waste was involved. When found, however, the rays were noted as being in bundles of 1, 2, 5, 6, 8, 9, 10, 12, 15, 22, and all very strongly built. In the fossil state, the rays, as they cross the tracheids, communicate by a single perforation that occupies the whole of the crossing space, and may have done so in life, although a network of small apertures might have so commingled. Against the latter idea, however, must be set the fact that all the tracheid-bordered pits are perfectly preserved, and many modern pines still adopt the single aperture plan. The ray pits in *Araucaria cunninghami* are quite often bordered pits, even when the tracheids on either side of the ray band are devoid of pits. These in tangential section give very clear proof of their structure! As I cannot, in the fossil, trace multiple pits, nor evidence of there being bordered pits in the rays, I shall record the ray pits as being the full size of the ray-tracheid crossings.

The bordered pits in the tracheids are in double rows, and run throughout their length without any special crowding at the ends. Now and again an end may develop three rows of pits, with very slight dilation, but without the oval termination seen in Araucarian pines. On the whole, the tracheid ends meet and blend with very little upward or downward displacement, and some junction by direct harmonia. Where the ray bands are widely separated the wood roughly suggests the Araucarian habit, but where the bands are numerous it recalls *Agathis*.

#### TANGENTIAL.

No tracheid-bordered pits have been detected in this aspect of the wood, and the medullary ray evidence is not as satisfactory as that obtained from the fortunate fracture in transverse section. The ray elements in single tiers have been detected, but where two or more tiers existed the evidence is obscure, even under the best microscopy, since all the elements seem compressed into a single mass.

As far as is known to me no pine of this age has been listed for Tasmania under the generic name of *Dadoxylon*, although our coal measures frequently yield leaf impressions of *Næggerathiopsis*, which Newell Arber regards as being the foliage of these conifers ("The Glossopteris Flora," page 191), rather than that of *Cycas*, as suggested by Fiestmantel.

#### TAXONOMIC.

Genus — *Dadoxylon*. Species — *penmani*. (Sp. nov. — Extinct.)

From the Tasmanian Permo-Carboniferous, and the oldest plant-yielding horizon as yet explored.

Three cotypes in Queen Victoria Museum, Launceston.

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#### ADDENDUM.

The microscopy has been done with the stereoscopical binocular and the best lenses, fitted with Lieberkuhns, up to powers as high as the  $\frac{1}{4}$  of an inch, the material being factured.

# ON AN UNUSUAL FORM OF STONE FROM A TASMANIAN NATIVE CAMP.

By

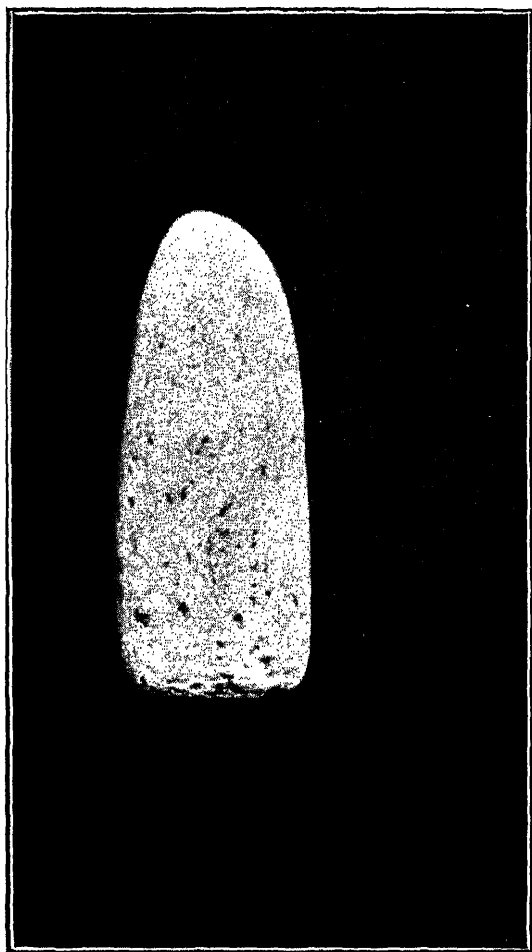
H. STUART-DOVE.

Plate III.

(Read 25th September, 1933.)

Until seven or eight years ago there existed a very interesting native camp-site just to the west of Mersey Bluff, a diabase headland which projects into the sea about a mile from Devonport town. This site comprised: a chipping-mound, where the implements were shaped from pebbles of various composition collected on the beach; a feeding-ground between the mound and a belt of sand which shut off the camp from the sea-winds; and a fresh-water lagoon on the other or land side of the camp, which lagoon was in former days overhung by tall swamp tea-tree. Thus the natives had everything at hand to make life pleasant—warm sand to bask in, fresh water to drink, plenty of shell-fish in the salt water and marsupials in the scrub, and an inexhaustible supply of large pebbles—chert, breccia, and quartzite—from which to fashion their hand-axes and scrapers. Before the site was destroyed by sand-carters, I collected there a number of neat little axes and knives, and a quantity of scrapers of various types; also a flat, circular pounding-stone, the top of which was protruding above the sand; when excavated, it proved to have in its centre some of the red ochreous material still adhering, which had been pounded by it, and used for decorative purposes by the men.

The most unusual find on this site was a stone of cylindro-conical type, which was lying on the surface; a number of these have been collected in the Darling Valley and other parts of New South Wales, and a correspondent in that State who has a large collection writes me that some have come to light in Africa and one in New Zealand. The specimen found at the Bluff camp appears to be the only one so far recorded from Tasmania, so that the distribution is strange and interesting.



[H. Stuart-Dove Photo.]

Cylindro-conical Stone Found on Site of Old Native Camp at  
Mersey Bluff, N.W. Tas.



According to the Ethnological Guide to the National Museum, Melbourne, the New South Wales specimens are composed of either slate or sandstone, and a feature peculiar to them is the saucer-shaped base. The Tasmanian specimen has not this hollowed base, but an attempt seems to have been made to produce it, as a chip has been taken out at one side of the base and a slight indentation made on the opposite side, as if with the intention of lifting out a large flake, but the material, an intensively hard breccia-quartzite, resisted the crude implements of our natives, and the flake was not removed.

These cylindro-conical stones were almost certainly put to some ceremonial use, but to what exact form of ceremony has not been determined. The Guide already quoted states that they have been variously designated as ceremonial stones of some nature, pounders, phallic symbols, or grave-markers. Both the correspondent in New South Wales and myself consider it highly probable that they were phallic emblems, which were employed, in some form or other, by so many primitive peoples.

The dimensions of the Mersey Bluff specimen are—

Length, 180 m.m.

Diameter at base, 71 m.m. (approximately).

Diameter at centre, 65 m.m. (approximately).

Diameter near the blunt top, 46 m.m. (approximately).

Weight, 3 lb. 9½ oz.

NOTES ON THE HABITS OF THE EXTINCT  
TASMANIAN RACE.

[No. 3.]

By

W. L. CROWTHER, D.S.O., V.D., M.B., B.S.

Plates IV.-V.

(Read 11th September, 1933.)

INTRODUCTION.

It is not proposed in this paper to attempt any detailed description of the method by which the Tasmanians disposed of their dead, but rather to give a brief account of the discovery of aboriginal remains at Sandford during April, 1927.

On the 12th of that month Mr. Alfred Morrisby showed me a cranium that he had found partially exposed in his orchard some days before. This orchard had been under cultivation for between 20 and 30 years, and had been ploughed six months previously.

It is possible that the cranium was turned up at that time, and the injuries it had sustained were inflicted by the ploughshare.

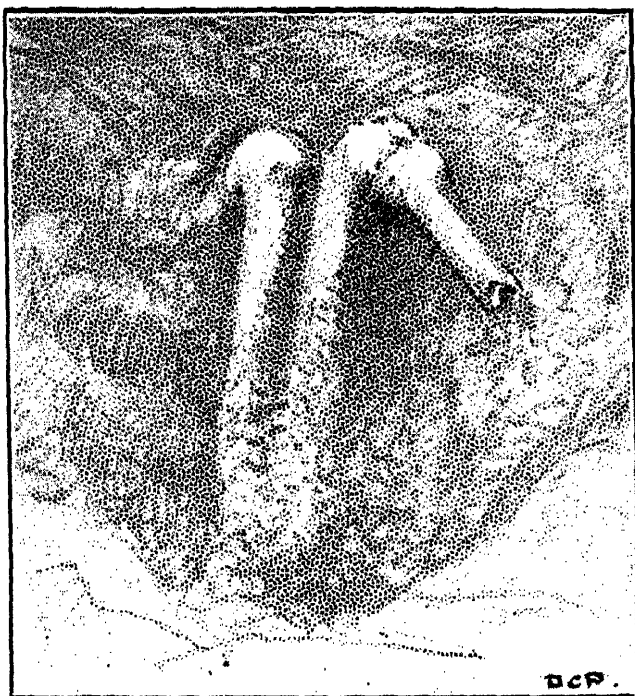
The presence near-by of a spring of fresh water and the abundant remains of oyster shells clearly pointed to the fact that it was on the site of an aboriginal camping-ground.

Four days later, in the company of Dr. Inglis Clark, a detailed examination of the locality of the find was made.

DESCRIPTION.

The cranium—No. 86, Tasman Series (Wunderly and Wood-Jones, 1933)—showed the characteristics of the Tasmanian type, and was that of a male of full adult age. The teeth were complete, except for the upper central incisors, which had dropped out.

When found it was on the left side, with portion of the left occipital area exposed.



Illustrating the Strongly Flexed Portion of the Bones of  
the Left Side.





The right temporal area was very friable, and the zygoma, outer wall of the orbit, and a considerable area of the superior maxilla of the same side, wanting (as a result of weathering or trauma).

The cranium was heavy and sodden with moisture and the cerebral cavity filled with sand.

The slight depression from which the skull had been lifted some days previously showed small pieces of bone scattered over an area of about 2 square feet. Interest was at once aroused by the fact that they had been broken into pieces not longer than 3 to 4 inches in length and showed traces of exposure to fire. One fragment was from the right scapula, others of more dense structure were probably parts of the humerus, radius, and ulna of the same side.

It is difficult to account for the broken-down condition of these bones, except by deliberate repeated fractures following partial incineration—crushing or accidental trauma does not appear to have been the cause.

A few feet away from these fragments nodules and a flat piece of red ochre were found—brought almost certainly from considerable deposits of ochre in the face of a steep bank of the adjacent lagoon.

Having carefully looked over the surface, we commenced to dig with our hands and a small entrenching tool.

Two areas of sand, each of about one cubic foot, were found to be discoloured by carbon and ashes.

Extending the search 4 feet away more bones were recovered, proving to be parts of several vertebræ (cervical and thoracic), two clavicles, a mandible in two pieces (less the ramus of the left side), and small portions of ribs.

Under these fragments a more solid mass was to be felt, which, on careful removal of the sand, proved to be a most interesting grouping of bones.

There were—

- (1) The proximal portion of the left humerus, with adjacent articular area of the scapula.
- (2) The distal portion of the femur of the same side, with the patella attached.
- (3) The proximal portion of the tibia.

Their relationship was as shown in Plate IV., and drawn from a very poor photograph taken at the time.

The bones of the leg were flexed at the knee to such an extent as to bring them into the closest contact. The body as a whole must have been placed in a position of marked flexion (Plate V.), as the head of the humerus was in intimate contact with the sharply flexed knee. To attain this result the knees must have been tucked up until almost under the chin, either before the onset of rigor mortis or after decomposition had set in.

Calder (1875) states that before incineration the Tasmanians were observed to tie the limbs in this way by thongs of rushes or grass.

#### THE POSITION OF THE BODY.

It was on its left side, the plane horizontal or with a slight inclination towards the vertical.

The level at which this group of bones was found was about 18 inches below the surface.

Detailed search, whilst revealing no trace of such bones as the lower thoracic or lumbar vertebræ, those of the pelvis, or below the middle of the tibia, showed a large area of sand, discoloured by fire, and containing ashes, indicating an attempt to dispose of the body by burning.

Through some want of fuel or shift of wind the incineration was incomplete, destroying only that part of the body below a line drawn obliquely across the upper thoracic vertebræ (see unshaded area in Plate V.).

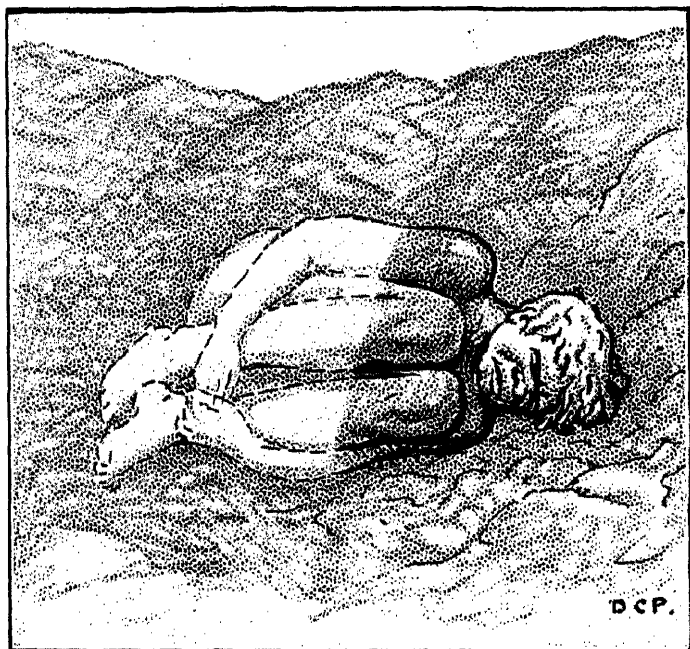
This would leave undestroyed the bones already described, the ashes representing the remainder which had been incinerated.

#### CONCLUSION.

We know from several eyewitnesses of funeral ceremonies at Bruny Island and at Whybalena that the Tasmanians disposed of their dead by burning or by depositing the body in a position of strong flexion in a hollow tree.

In both these procedures it was customary to place the body in an upright position. In other instances (usually with children) the parents carried certain bones or wore them suspended around their necks.

The discovery at Sandford confirms the evidence as to the strongly flexed position of the body before incineration, and shows that in this instance the latter was lying on its left side, and not upright.



Supposed Position of Body. (Unshaded area shows complete incineration.)



As this is the first occasion since Peron (1809) upon which such human remains have been discovered, it seems only fitting that the details be placed in record.

## REFERENCES.

- PERON, M. F. 1809. "A Voyage of Discovery to the Southern Hemisphere." Page 207, *et seq.*
- CALDER, J. E. 1875. "Some Account of the Wars, Extirpation, Habits, &c., of the Native Tribes of Tasmania." Page 27, *et seq.*
- J. WUNDERLY and FREDERIC WOOD-JONES. 1933. "The Non-Metrical Morphological Characters of the Tasmanian Skull." *Journal of Anatomy*, Vol. LXVII.

# NOTES ON A MEMORIAL TO ALFRED BARRETT BIGGS, ASTRONOMER.

By

A. L. MESTON, M.A.

(Read 25th September, 1933.)

The latitude of Launceston is officially given as  $41^{\circ} 26' 1''$  south and the longitude as  $147^{\circ} 7' 49.5''$  east, but there is at present not the slightest indication of the position from which those calculations were determined. It is proposed by the Northern Branch of the Royal Society to mark the position adequately and fittingly by the erection of a pillar suitably inscribed. The observations were made by the late Mr. Alfred Barrett Biggs, F.R.S., who for many years had an observatory in what was then called the Depot Grounds, but which to-day is termed Royal Park. Mr. Biggs was one of that noble band of amateur scientists to whom the world owes so much. He was born in London on the 10th of April, 1825, and was the eldest son of Mr. Abraham Biggs, builder and contractor. He arrived in Hobart Town with his parents in 1833. As a youth he joined the staff of the Commercial Bank of Tasmania at Hobart, but subsequently resigned in favour of teaching. He held good positions in the State Departments of Victoria and Tasmania for over 27 years. In 1880 he entered the Launceston Bank for Savings as accountant, a position which he filled with distinction until a few weeks before his death on the 19th of December, 1900.

Seismology and astronomy were the subjects that lay nearest to his heart. On a convenient site in Royal Park he set up a freestone pillar, and built over it an octagonal observatory with a revolving roof. When the American astronomical expedition visited Tasmania in 1874, to observe the Transit of Venus on December 9th of that year, it was natural that Alfred Biggs should become intimate with the astronomers. So highly did they think of his work that on their departure they presented him with the transit house used by them. This he set up beside his observatory. Here in Royal Park he did splendid work, winning international repute. In 1884 he contributed his first astronomical paper

to the Royal Society—"Spectroscopic Observations of Comet 'Pons'." From then on he was a regular contributor. His papers—"Report of Spectroscopic Observations of the Twilight Glows during February and March" (1884), "Tasmanian Earth Tremors" (1885), "The Star 'Alpha Centauri'" (1887), "The Occultation of Jupiter," "Is Jupiter Self Luminous?" (1886), "A New Dark-field Micrometer for Double-star Measurement," "Observations of Comet of July and August" (1889), "Recent Measures of 'Alpha Centauri'" (1889), "The Eclipse of the Moon" (1891), "The Transit of Mercury" (1891), "The Possibilities of the Telescope" (1891)—show to some extent his activities. The main telescope he used was a fine instrument, an 8½-inch reflector (Newtonian), which at his death he bequeathed to the Royal Society.

He took a keen interest in mechanics generally, showing remarkable skill in both theory and practice. One of the transit instruments used in his observations was made entirely with his own hands; his microscope was entirely his own work, even the lenses and eye-pieces being ground by him.

When Alexander Graham Bell discovered the principle of the telephone in 1876, he described his invention at length in "The British Mechanic." Alfred Biggs read this with interest. At once he constructed sets. Keeping one set at Launceston, he forwarded another to Campbell Town, and tried out the invention. It was a complete success, the reception and transmission being equal to those of any modern instrument. This was, I think, the first telephone used in Australia. Such an experiment exemplifies his technical skill and his keen interest in general scientific pursuits. Among other examples may be mentioned a master electric clock, 6 feet high, and accurate to the second, which drove other clocks minute by minute.



## PRELIMINARY NOTES ON A ROCK SHELTER IN EASTERN TASMANIA.

By

F. HEYWARD, F.R.A.I.A.

(Read 25th September, 1933.)

The cave or shelter occurs in the cliff walls of the gorge of a small rivulet that is one of the tributaries of the Little Swanport River.

The creek-bed varies greatly; sometimes running through open country, and then turning abruptly and passing between freestone cliffs 80 to 100 feet high. In fact, the stream, though normally a small rivulet, appears in places to cut across the natural features of the country-side.

The shelter in question occurs just before the rivulet leaves one of the gorge sections of its course to meander through a wide, flat valley bottom of deep black soil. This valley probably fed many kangaroo when the aboriginals were wandering there. The natives did pass along it, because the writer has found many implements at the lower end of the valley, as well as along its course and far beyond the rock shelter.

It is improbable that they used the gorge section of the river-bed as a thoroughfare. At the present time it is very rough in places, and, from various indications, would then probably be choked with scrub and trees. At this day it is easy to short-circuit this rocky section, and it appears likely that the natives did this. If this is true, then it is clear why so few artefacts were found in the sand of the shelter floor.

The cave was not generally used by the aboriginals, nor was it on the main road or travel-line of the tribe. From its position it might almost have been a refuge or hiding-place—at any rate, from white settlers. It appears to have been ideal for such a purpose. At the point where the stream emerges on to the black-soiled valley bottom before mentioned the rocky gorge is running approximately north and south. If one stands on the flat facing into the opening and up the stream, he is faced with these features: on the

right a very steep, cliff-crowned hill, perhaps 150 feet high; on the left is a similar hill, but lower; these extend, respectively, roughly east and west, and are clothed with gums, wattle, and other scrub. Probably the distance across the gorge at the top of the talus-like slopes and at the base of the cliffs would be 60 to 70 yards.

Almost at the entrance the gorge is blocked by the trunks of old fallen trees and a steep rocky face, over which the stream forms a waterfall.

The shelter occurs perhaps 70 or 80 yards from the entrance and in the cliff portion of the eastern side. At this point the creek runs closer to the western bank, and there is a steep earth and rock slope from its bed up to the foot of the cliff on the eastern side; this slope is covered with scrub and tall trees.

The shelter is in the face of the eastern cliff, and thus looks west, but must have been well protected before the fires of settlers penetrated and burnt the bush.

The floor of the shelter is at varying heights from the base of the cliff, the earth sloping from north to south, and at the highest point must be 9 or 10 feet below the cave floor, whilst at the northern end the height is only 3 or 4 feet.

The shelter is naturally divided into two parts. At one end the shelf that forms the floor is about 5 feet 6 inches wide; but here there is practically no ceiling; the rock slopes from the back of the floor at a steep angle till it nearly reaches the top of the cliff. The length of this part of the cave would be 8 or 9 feet.

The portion of shelter further north has a species of ceiling, and is more in the nature of a cave. One may stand up at the outer edge of the floor, which might be 3 feet 6 inches wide. This part of the cave is about 7 or 8 feet long. The floor slopes upward from the south to the north, and leads naturally towards the cliff-top at the east side of the entrance to the gorge. At this point there is a natural lookout, giving a view through the tree-tops over the wide valley bottom mentioned before.

Returning to the shelter. There is evidence of fires having been built on the floor, for in both portions the freestone back has two clearly marked spots, where fires frequently lit have left their mark, in the shape of a change of colour in the freestone from yellow to red. Of course the erosion of the winds and damp of years have removed any trace of soot.

When the writer entered, the sand on the floor was even and smooth, except for the track of some animal, and under a little projecting ledge of rock was an abandoned nest of small sticks, &c., whilst near-by were a few whitened bones of a small animal.

On the outer edge of the part of shelter furthest north were three or four artefacts, lying as though they had been left there by the last user—one was nearly falling from the edge of the floor into the bush below. The sand of the floor at this point yielded several more—one or two buried 6 or 7 inches deep. Fine black dust and a few old pieces of burnt bone are mixed all through the sand.

Behind where the fire must have been was a small flattish stone, sized roughly 9 inches by 7 inches, and placed level and parallel with the back of the shelter. This was remarkable because of the absence of other large stones.

The artefacts are all rather small and comparatively neatly formed. Other scrapers found in the neighbourhood are much bolder in design.

The implements are interesting, as affording examples of most of the ordinary types found in Tasmania. They are as follows:—

1. Side scrapers,  $3\frac{1}{2}$  inches long, worked full length of one side.
2. End scraper,  $2\frac{3}{4}$  inches long, worked at point (approximates to Aurignacian type).
3. Awl, worked to good point. One side may have been of service as concave scraper  $2\frac{3}{4}$  inches long.
4. Stone similar to oval "oyster" or thumb stone types, though not finished on one side.
5. Roughly heart-shaped stone, top edge concave.
6. Broadened end scraper—a good edge, well chipped, rest of stone roughly shaped.
7. Nondescript stone, very thin, but with delicate chip-pings on edge.

# OBSERVATIONS ON SOME TASMANIAN FISHES, WITH DESCRIPTIONS OF NEW SPECIES.

By

E. O. G. SCOTT, B.Sc.,

Assistant-Curator, Queen Victoria Museum, Launceston.

Plates VI-VIII.; and Two Text Figures.

(Read 25th September, 1933.)

## SCOPE.

The present paper deals with material that has come under observation in the course of Museum routine. It falls into three sections—

(a) Some general observations; species mentioned being *Regilophotes güntheri*, *Phyllopteryx foliatus*, *Cephaloscyllium isabella*, *Urolophus viridis*, *Anguilla reinhardtii*, *Solegnathus fasciatus*, *Galaxias affinis*. In view of the scant attention our Tasmanian fishes, except in so far as they come within the purview of general Australian ichthyology, are at present receiving, it has seemed worth while to record these notes, and, though their incidental nature is fully realised, to give them in enough detail to render them reasonably self-sufficient memoranda, available when the need for them arises.

(b) Additions to the Tasmanian list: *Econanutes cribrosus*, *Solegnathus robustus*.

(c) Descriptions of a new species of *Galaxias*, and a new species of *Agrostichthys*, the latter, incidentally, constituting the first Australian record of the family Agrostichthyidæ.

Except where otherwise stated, the registration numbers are those of the Queen Victoria Museum, Launceston, Tasmania.

## REGILOPHOTES GÜNTHERI (Johnston).

*Lophotes güntheri* Johnston, Pap. and Proc. Roy. Soc. Tas., 1882 (1883), pp. xlv., 142, and 176.

*Regilophotes güntheri* (Johnston), Whitley, Rec. Aus. Mus., XIX., I., Aug., 1933, p. 72.

Johnston's type of *Lophotes güntheri* was obtained "near Emu Bay," North-Western Tasmania. A contemporary news-

paper account of it, *ex* Johnston MS., has been made available by Whitley (1928, p. 50).

Australian and New Zealand records of Lophotidæ are few, Whitley (1933, p. 72) is of the opinion that the New Zealand records (Waite, 1914) of *Lophotes cepedianus* and *L. fiskii*, and the Victorian record (Kershaw, 1909) of *L. cristatus* Johnson, a Madieran species, probably all refer to Johnston's *L. Güntheri*. Remarking that "the very distinct Australian genus evidently requires a new name," he institutes *Regilophotes* gen. nov.: orthotype, *Lophotes Güntheri* Johnston, 1883.

A topotypical specimen of *Regilophotes Güntheri* (Johnston) is in the Australian Museum, Sydney; Regd. No. B. 5776 (*vide* Whitley).

As any particulars relating to this rare fish are of interest, I give below such information as I have been able to collect on a topotypical specimen caught, on rod and line, at Cooe Creek, near Burnie, by Mr. P. Saunders, on 23rd September, 1931, and forwarded, through the kind offices of the late R. S. Sanderson, to the Museum. Unfortunately, the specimen, which had been exhibited for some time in a fish-shop, was found by the taxidermist to whom it was handed on its arrival to be beyond preservation.

In a letter dated 1st October, 1931, acknowledging the receipt of some observations on, and measurements of, the specimen, Mr. Sanderson made the following interesting comments:

"The close approximation to each other of the 1882 and 1931 specimens is very striking, but apart from that I can say positively that the two specimens might well be regarded as merely two units of a mass-production so much do they resemble one another. I saw the 1882 specimen on the rocky beach—about opposite the present Burnie Hotel—very shortly after some lads had discovered it (if I remember rightly it was not caught—at least, not by hook and line, and where it was lying was no place for a seine net), and have always retained a clear mental impression of its remarkable appearance. Consequently I had no hesitation in identifying the fish when called downstairs to look at the strange creature which some boys had brought in."

Speaking of the degeneration of the specimen through keeping, Mr. Sanderson observed:

"When first caught, the brilliant silvery gleam largely overpowered the salmon pink look which it had next day.

The eye when fresh was a beautiful object—of great depth and luminosity—more like that of some animal (the 'mild eyed kine' of the classics, for instance), and the dorsal fin was well defined."

On its arrival in Launceston, the fish was in general colour a rich pink or red, frosted over with sheer silver. In some regions the silver was dominant, being scarcely influenced at all by the underlying red; in others the rich background blushed through the argentine wash; the net effect being now that of silvered purple, and now that of purpled silver. This pomp of general body-colour was elegantly relieved by the lustrous brown-black of the head-region (particularly the opercle) and by the limpid dark-brown of the eye.

Some dimensions of the 1931 specimen (with corresponding measurements of the 1882 specimen in parentheses): Length, 44 inches (43½ inches); depth behind shoulder, 8½ inches (7½ inches); length of pectoral ray, 2 inches (2½ inches); diameter of eye, 2 inches (2 inches); greatest thickness of body, 1½ inches (1½ inches).

#### PHYLLOPTERYX FOLIATUS (Shaw).

*Syngnathus foliatus* Shaw, Gen. Zool. (Pisc.), V., 2, 1804, p. 456, Pl. clxxx. (*vide* Sherborn).

*Phyllopteryx foliatus* Günther, Cat. Fish. Brit. Mus., VIII., 1870, p. 196; *id.*, McCoy, Prod. Zool. Vict., dec. VII., 1882, pp. 19-20, Pl. lxxv., Figs. 1, 1a, 1b.

*Phyllopteryx altus* McCoy, Prod. Zool. Vict., dec. VII., 1882, p. 20.

(Text Figure 1.)

McCoy (1882) described and figured *Phyllopteryx foliatus* as having two small tags depending from the ventral surface of the snout. He notes (p. 19) the occurrence of "two minute spines on upper edge of snout, considerably nearer to the eye than the tip, and two slender filaments (often united) on under opposite side"; and his natural size, coloured representation of a "moderate specimen" (Pl. 65, Fig. 1) depicts these tags as two separate brown ribbon-like appendages, in the position described, and measuring, roughly, 7 mm. long and 0.5 mm. wide.

The presence of these tags has not, I think, been recorded by any other observer; and Waite and Hale (1921), in reviewing the Lophobranchiate material of the South Australian Museum, state (p. 315): "The small tags, as figured

by McCoy, beneath the snout, are not present in any specimen we have seen."

In a specimen (Reg. No. 952) netted at Stanley, North-West Coast, by Mr. T. B. Smith on 2nd October, 1932, one of these tags occurs, plastered on to the right side of the snout. Length, about 10 mm.; colour, black. Though quite narrow proximally, it expands distally to a width of about 2.5 mm.; its general shape suggesting a stalked, narrowly ovate-acuminate leaf. It would hardly be described as a "slender filament": though this expression applies quite well to the appendage as figured by McCoy. (See Text Fig. 1.)

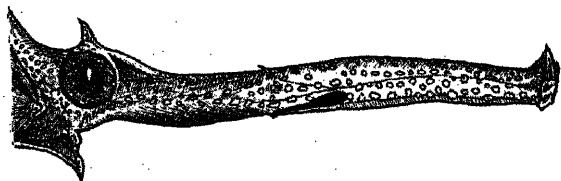


Fig. 1. *Phyllopteryx foliatus* (Shaw): Snout, showing Tag.  
(About natural size.)

An examination of this and other Tasmanian specimens suggests the following additions to, and enlargements upon, the excellent description of the species given by Waite and Hale.

Small spine on the nape, about midway between the occipital and nuchal appendage-bearing spines; sometimes a second, smaller, more anterior spine. Of the two small spines on the upper surface of the snout, one is commonly in advance of the other. "A small" bifid "spine on the front edge of the orbit." "A small patch of bristle-like spines below the hinder part of the orbit and a row of spines on the lower edge of the eye occasionally present," the bristle-like patch regularly including, in Tasmanian specimens, at least one conspicuous backwardly directed spine. Sometimes a row of small spines running forward along the supraorbital ridge from the two large supraorbital spines (which may be secondarily spined, and may have small spines round their bases). Occipital spine commonly with four distal spikes. Spines on dorsal body-ridge "strongest alongside the fin and almost obsolete on the dorsal arch," but usually well developed in advance of the latter. Of the spines on the paired ventral body-ridges, that of the antepenultimate body-annulus is much stronger than any others,

and is generally serrated; and that on about the fourth body-annulus is larger than its neighbours. "A pair of spines in front of the lower half of each pectoral base," with occasionally several smaller spines between them and the fin. Two or three spines above superior margin of preoperculum, that situated nearly below the appendage-bearing occipital spine being the largest. The inferior nuchal region in advance of pectorals, which McCoy describes as "swollen conically," tends to form, in dried specimens, a subrectangular platform: this bears spines at its posterior angle (commonly two pairs), at its anterior angle (one pair), and occasionally along the longitudinal diagonal (several rows; spines small). Total length reaches 388 mm. Appendage-bearing spines may be spotted or blotched with lighter colour, these spots and blotches being, like those on snout and elsewhere, translucent in dried specimens.

All the Tasmanian specimens that have come under my notice are of the deep-bodied type, in which the greatest depth of the body is equal to or exceeds the length of the snout, or the equivalent of about 10 body-rings, as against barely 0.75 of the length of the snout, or the equivalent of about seven body-rings, as in Shaw's original figure of *S. foliatus*. McCoy's *P. altus*, which is based on this feature, and on the marked difference in colour between the Victorian specimens, as shown in his own plate of *P. foliatus*, and the Tasmanian specimens, as shown in the painting by Mrs. Meredith (1880), has now been merged, seemingly with pretty general consent, with *Phyllopteryx foliatus* (Shaw): it is possible, however, that a survey of an adequate series of Tasmanian and mainland specimens might establish the validity of McCoy's species.

#### CEPHALOSCYLLIUM ISABELLA (Bonnaterre).

*Squalus isabella* Bonnaterre, Tabl. Encycl. Meth., Ichth., 1788, p. 6.

*Scyllium laticeps* Duméril, Rev. et Mag. Zool. (2) V., 1853, pp. 11 and 84, Pl. iii, Fig. 2 (head).

*Cephaloscyllium isabella* Gil., Ann. Lyc. Nat. Hist.; N. York, VII., 1862, p. 412.

In dealing with *Cephaloscyllium isabella*, Lord and Scott (1924, p. 22), after giving "Reference:—Waite, Trans. N.Z. Inst., 1909, XLIX., p. 384; McCulloch, 'Endeavour' Scientific Results, 1911, p. 6"—observe: "Recorded by McCulloch



from East Coast of Flinders Island, Bass Straits." McCulloch (*loc. cit.*) states: "A small example is in the collection which was trawled off the east coast of Flinders Island, Bass Strait."

As Lord and Scott's synopsis constitutes the most recent revision of the fish-fauna of Tasmania, and will form, it may be presumed, the basis for future work, it is perhaps worth while to call attention to the fact that this species, as *Scyllium laticeps*, is accredited to Tasmania by Günther (1870, p. 404), and appears in Johnston's list of 1882 (p. 138) and 1890 (p. 39).

It is apparently fairly common in Tasmanian waters. A specimen, having a total length of 885 mm., was secured in a graball at Penguin, North-West Coast, by Mr. W. J. Beaumont, on 18th June, 1933, and was received at the Museum (Reg. No. 964) the next day. It may be remarked, in passing, that this shark, after having travelled to Launceston by train in a sack, exhibited distinct evidences of life while being examined, and on being placed in fresh water at 4.15 p.m. on 19th June, revived sufficiently to breathe quite regularly and to move the pectoral fins and the tail. A specimen, 961 mm. in total length, was found by me washed up on the beach at Ulverstone, North-West Coast, on 4th August, 1933. Mr. J. A. Begent, B.Sc., informs me that this shark is frequently met with at Stanley, North-West Coast, where it is commonly referred to as the "Nurse" or "Grey Nurse"—a rather unfortunate vernacular name in view of the well-established association of "Grey Nurse" with species of *Carcharias*, including our own *C. arenarius*.

#### UROLOPHUS VIRIDIS McCulloch.

*Urolophus viridis* McCulloch, Biol. Res. "Endeavour," IV., 4, 1916, p. 176, Pl. li.

It is of interest to note the presence in the Museum of an Old-Collection spirit-specimen (Reg. No. 971a) of this species, dating back at least 36 years, and originally determined as *Narcine tasmaniensis*. Total length, c. 197 mm.; disc-width, c. 123 mm.

#### ANGUILLA REINHARDTII Steindachner.

*Anguilla reinhardtii* Steindachner, Sitzb. Akad. Wiss. Wien, LV., I., 1867, p. 15, Figs. a-b.

*Anguilla marginipinnis* Macleay, Proc. Linn. Soc. N.S. Wales, VIII., July 17th, 1883, p. 210.

*Anguilla reinhardtii* is not included in either of Johnston's lists; and Günther (1870, p. 27) gives as its range "North-eastern Australia."

This species is, however, accredited to Tasmania by Lord (1922, p. 64), Lord and Scott (1924, p. 36), and McCulloch, "Rivers of Eastern Australia (Queensland to Tasmania)" (1929, p. 64); but on just what records these attributions are based I am unable at the moment, through lack of literature, to determine.

On the other hand, Schmidt (1928) says of *A. reinhardtii* (p. 193): "in Tasmania it has not yet been observed"; and in his chart of "Distribution of the Australian eels according to the examination of a number of samples consisting of about 900 specimens" (Fig. 13) he also represents our only species as being *A. australis*. Among the 928 specimens of *Anguilla* examined by Schmidt were "51 from Tasmania, including Flinders and Vansittart Islands" (p. 192).

In view of the element of uncertainty introduced by the statement of so eminent an authority on the genus *Anguilla* as Schmidt, the following facts seem worthy of record.

In the Museum are three long-finned eels from Longford, 20.3.1908; Cataract mill-race, Launceston, 25.8.1908; and "near Launceston," 1928 (Reg. Nos. 946, a, b, and c). These specimens, which were preserved on account of their unusually large size, measure 1635, 1525, and 1531 mm. in total length.

In 1932 I brought these specimens under the notice of Professor Schmidt, and forwarded to him a note on their  $\frac{a-d}{t} \times 100$  values ( $a$  = length to vent;  $d$  = length to origin of dorsal fin;  $t$  = total length). The factors for these three specimens are, as nearly as can be determined, 11.4 ( $a$  = 688 mm.,  $d$  = 501 mm.,  $t$  = 1635 mm.), 11.2 ( $a$  = 647 mm.,  $d$  = 476 mm.,  $t$  = 1525 mm.), and 10.8 ( $a$  = 682 mm.,  $d$  = 517 mm.,  $t$  = 1531 mm.). Schmidt determined the  $\frac{a-d}{t}$  percentages for *A. australis f. occidentalis* as from -1.5 to +4.0, average 1.27; and for *A. reinhardtii* as from 7.8 to 13.2, average 10.72.

Concerning these eels, Professor Schmidt remarked (*in litt.*): "From the  $\frac{a-d}{t} \times 100$  values stated by you, I have no doubt that the specimens really belong to this species" [*A. reinhardtii*]. At the same time, he called attention to the possibility of *A. aucklandi*, whose known range is sur-

prisingly restricted, reaching our waters, stating: "There seems to be reason to keep a sharp look-out for this species in Tasmania."

Without an anatomical examination, there is little to distinguish *A. reinhardtii* from *A. aucklandi*. On the whole, however, the evidence afforded by external features and teeth seems to indicate that the present specimens are to be relegated to the former species.

Unfortunately the death during the present year of Professor Schmidt prevented the completion of an arrangement I had entered into with him to submit for his detailed examination a further series of Tasmanian specimens.

Fishermen inform me that both *A. reinhardtii* and *A. australis* are common in Tasmania, the opinion commonly being held that the distribution depends upon the nature of the river, either as a whole or in given sections, the former species preferring a sandy or gravelly, the latter species a muddy, bottom.

In his paper cited above Schmidt remarks (p. 193): "It would be useful in the work of further research if zoologists or other interested parties in Australia would endeavour to ascertain the length and weight attained by *Anguilla reinhardtii*." After quoting reports of eels up to 30 lb. in weight from "Eastern Victoria," and of up to 20 lb. from the Tambo River, East Gippsland, Victoria, he observes: "It will be apparent from the above that I have not personally seen any specimens of *Anguilla reinhardtii* over 135 cm. in length and 6.7 kilograms in weight. It is most likely, however, that the larger eels, of 20 or 30 lb. weight, noted above belong to this species rather than to *Anguilla australis*. In any case, it is remarkable that eels of this size should be specially noted as occurring only in the eastern part of the State of Victoria, for *Anguilla australis* is, as we have seen, extremely common also in the western part."

The three Museum specimens of *A. reinhardtii* have, as already noted, a total length of 1635, 1525, and 1531 mm., as preserved. The register records that the weight of the Longford specimen (Reg. No. 946a) was 34 lbs.; of the Cataract mill-race, Launceston, specimen (Reg. No. 946b) 28 lbs.; while the weight of the specimen from "near Launceston" (Reg. No. 946c) is entered as "said to be 42 lbs."

It should be observed that Johnston (1883) says of *Anguilla australis*, "Reaches to an immense size in the South

Esk River" (p. 133); and, again, "Some of the eels have been taken in the Ringarooma and South Esk Rivers over 30 lbs. in weight and over 20 inches in girth" (p. 61).

Mr. I. Tyler, fishmonger, Launceston, informs me that there passed through his hands, during the latter half of 1932, a short-finned eel, caught at the Power Station, South Esk River, near Launceston, that measured about 5 feet in length, and weighed 36 lb.

#### SOLEGNATHUS FASCIATUS (Günther).

*Solenognathus fasciatus* Günther, Rept. Voy. "Challenger," Zool. I., 6, 1880, p. 80, Pl. xiv., Fig. B.

The locality of this species, the type of which was secured by the "Challenger" off Twofold Bay, is given by McCulloch (1929) as New South Wales.

Its appearance in the Tasmanian lists of Lord (1922) and Lord and Scott (1924) is apparently based on the collection by the "Endeavour" of specimens "South-east from Babel Island, off Flinders Island, Bass Strait" (McCulloch, 1911).

In these circumstances, it may be noted that the Museum collection includes a specimen (total length, c. 350 mm.) from Scamander, East Coast (Reg. No. 951z).

#### GALAXIAS AFFINIS Regan.

*Galaxias affinis* Regan, Proc. Zool. Soc., Lond., 1905, II., (April 5th, 1906), p. 380, Pl. x, Fig. 1.

This species (type-locality, Lake St. Clair) is omitted from the published Tasmanian lists, all of which are in need of revision.

#### EXONAUTES CRIBROSUS (Kner).

(*Exocoetus*) *cribrosa* Kner, Reise Novara, Fische, III., 1867, p. 328. Alternative name of *E. unicolor* Kner, regarded as possibly distinct from *E. unicolor* Cuvier and Valenciennes, (*vide* McCulloch, 1929).

*Exonastes fulvipes* Ogilby, Proc. Roy. Soc. Qld., XXI., 1908, p. 8.

On the afternoon of Tuesday, 13th May, 1930, a live flying-fish was captured at West Bay, River Tamar, by Mr. R. S. Allison, who in a covering letter says: "I was standing near the beach when the fish rose from the water and flew

a short distance, when the strong southerly wind threw it back on the rocks, where I ran and caught it."

The specimen, which has a total length, as a formalin preparation, of approximately 295 mm., appears to be a fairly typical example of *Exonantes cribrosus* (Kner). Reg. No. 975.

First record of the species—and, *fide* McCulloch (1929), of the family Exocoetidae—for Tasmania.

SOLEGNATHUS ROBUSTUS McCulloch.

*Solenognathus spinosissimus* Zietz, Trans. Roy. Soc. S. Aus., XXXII., 1908, p. 299 (not of Günth.).

*Solegnathus robustus* McCulloch, Zool. Res. "Endeavour," I., 1911, p. 28, Pl. ix, Fig. 2.

This species was described by McCulloch from a single specimen "from 37 fathoms off Flinders Island, South Australia, August 30th, 1909." Waite and Hale (1921), who regard the South Australian specimens determined by Zietz (1908) as *Solenognathus spinosissimus* Günther as belonging to this species, state (p. 313): "Specimens are known from Corney Point, Pt. Lincoln, and Flinders Island [i.e., Flinders Island, S. Aus.], the longest being 364 mm."

The present notice of a dried specimen from Blue Rocks, Flinders Island, Bass Strait (Reg. No. 953), constitutes the first record for Tasmania.

It is perhaps as well to point out that the present note in no way affects *Solegnathus spinosissimus* (Günther), the position of which on our list is well established: a specimen of this species from Tamar Heads is in the collection (Reg. No. 952).

In dealing with *S. robustus*, Waite and Hale point out that whereas McCulloch (1911) gives the head as "3·7 in the trunk," his figure shows 2·7 is intended: in the present specimen the value is only 2·4. McCulloch says, "Length of tail a little less than the distance between the vent and the pectorals": but Waite and Hale observe, "The length of the tail is subject to slight variation; in two of our examples it is less than the distance between the vent and the pectoral fin, in the third it is as long as the trunk." In the Tasmanian example the tail is 1·08 times the trunk. As, however, the trunk is relatively shorter in this specimen than in the others described, the tail is not significantly

longer, relative to the total length, than in McCulloch's specimen, the ratio in that case, calculated from the other proportions given, being 2.3 (2.31), and in the present instance 2.4 (2.37).

The greater relative depth of the snout, and of the tail immediately behind the dorsal fin; the radiating rows of spines on the scutes; and the more imperfect attainment of the dorsal profile by the main lateral row of spines (an attainment delayed, in the specimen, till about the twenty-fifth caudal annulus)—the chief characters that serve to distinguish this species from *S. fasciatus*—are well marked in the present specimen. The length of the base of the dorsal fin, which McCulloch gives as "almost equal to the distance between the tip of the snout and the posterior border of the eye," is here 0.98 of that distance; while, it may be observed, the corresponding value in the case of *Solegnathus fasciatus*, determined from the specimen from Scamander, previously mentioned, is only 0.79.

Total length of specimen, 358.5 mm.

#### Family GALAXIIDÆ.

Genus GALAXIAS Cuvier, 1816.

*Galaxias* Cuvier, Regn. Anim., ed. 1, II., "1817" = Dec. 1816, p. 183. Haplotype, *Esox truttaceus* Cuvier.

GALAXIAS CLEAVERI, sp. nov.

[Plate VI.]

#### (a) History of the Specimen.

The history of this specimen is of some interest, both in itself and for the incidental light it throws upon the habits of the Galaxiidae generally.

On the 23rd December, 1932, a eucalyptus stump, about 2 feet through, was blown out of the ground by explosives at West Ulverstone, North-West Coast, and on cutting up some of the wood for household purposes on 8th January, 1933, Mr. F. Cleaver found the fish in a root about 8 inches in diameter. The root, which was just damp, contained a cavity, in the middle of which the fish was lying. Mr. Cleaver says he has no idea how it got into the log, which was prone on the surface of the ground. He states: "There is no running water for about a quarter of a mile, but all through the

winter there is water lying in ponds close to where the stump stood in swampy ground."

The fish was kept alive in a tin of water, the tin being sunk in the garden, with the top flush with the ground. On one occasion, the specimen, which was always prone to jump out of a vessel in which it was placed, was missing from its tin, and was later found happily wandering about, some distance away, among the tomato-plants. While in its discoverer's possession, its longest spell out of water was 12 hours. As far as Mr. Cleaver is aware, no other fish of the same kind has been met with in the vicinity.

At the suggestion of Mr. H. Rodman, the fish was secured for the Museum. It was forwarded from West Ulverstone, by service car, in a bottle of water, and came to hand alive on Tuesday, 4th April, 1933.

On its arrival at the Museum, it was transferred to a bucket filled to a depth of about 4 inches with tap-water, in which were placed bread-crumbs—an item of diet to which Mr. Cleaver had found it readily took. During the afternoon it was placed on a table, where it remained, occasionally leaping, at no great height, for a distance of several inches, for seven minutes, every now and again gulping in a mouthful of air. Though it exhibited no marked signs of distress, retaining the normal upright position without difficulty, it is of interest to note that, seven minutes after it was returned to the water, its rate of respiration was 42 per minute, whereas in another eight minutes the rate had increased to 56.

After being kept alive in its bucket for just over a week, the specimen was embedded at 2.30 p.m. on Wednesday, 12th April, in well-moistened earth, where it remained for three-quarters of an hour, apparently without suffering any discomfort, but becoming decidedly darker in general colour in harmony with its surroundings. At 3.15 p.m. it was taken out of the damp earth, washed, drained of excess moisture, and placed in a perfectly dry watering-can, the top of which was covered with newspaper perforated with several holes.

When examined the next morning, Thursday, at 9 o'clock, it was still very evidently alive, but apparently disinclined to make much movement. On being taken up, however, it at once began to move in very lively fashion—being excited, very possibly, by the warmth of the hand—and, when placed on the table, continued vigorously to leap about. After a few moments it was returned to its can.

On Friday morning the fish was still obviously alive, but during the day it began to shrivel up. By Saturday morning, at 9 o'clock, it presented much the appearance of a dried-up worm, the whole body being shrunken and wrinkled. As, after repeated tests, it gave no obvious evidence of life, it was placed in formalin. Immediately on coming into contact with the liquid, it revived, and demonstrated its vitality by several vigorous plunges, only to be overcome, in a few moments, by the preservative.

In this test, therefore, the fish first remained alive for three-quarters of an hour in damp soil. It then lived in a dry vessel from Wednesday, 12th April, at 3.15 p.m., till Saturday, 15th April, at 9 a.m.—i.e., for 65½ hours. Even then, as has been noted, it was not dead, but, as events proved, merely very quiescent. It seems not at all unlikely that had the fish been kept even barely moist, it might have survived for a longer, possibly much longer, period.

(b) *Ability of the Galaxiidae to Live Out of Water.*

The New Zealand *Neochanna apoda*, of course, burrows in damp clay, and it has been stated that it soon dies if placed in clear water.

T. S. Hall (1900) gives an account of a burrowing *Galaxias* from Strahan, Tasmania, found in "decayed peat and sand, eight inches below the surface." The only description given of the fish, the species being undetermined, is as follows: "It is a slender form, and is marked by chevron-shaped dark bands of small spots, which mark out the myotomes in the middle of the body, but become irregular towards the head and tail. Its total length is 44 mm." He also notes: "Fish are reported as being occasionally dug up in the button-grass country, on the west coast of the island, and are stated by a miner to have no eyes, though otherwise similar."

I have spoken with several people who have encountered this burrowing *Galaxias* on the West Coast; but I have not so far been able to secure a specimen. I am informed that about 30 years ago numbers were dug up in the grounds of the State school residence at Strahan.

It seems not unlikely that our little native trout generally, living as they often do in small creeks that periodically become partly or wholly dry, have been driven by the conditions of their existence to acquire, to a greater or lesser extent, the power of burrowing and the ability to survive



for considerable periods in damp earth. Mr. R. Slater, of Kelso, informs me that a *Galaxias* is sometimes met with on his estate, some distance below the surface in dried-up waterholes.

That native trout will frequently revive on being thrown into water, after lying for some hours in a bag or basket, is a fact with which many fishermen are familiar. A specimen of *Galaxias truttaceus*, placed in the dry vessel used previously in the experiment with Mr. Cleaver's fish, was found to be very much alive after 19 hours. On being supplied with water, it opened its gill-covers widely, and in about a minute was swimming round blithely, and breathing in normal fashion. If its degree of vitality after 19 hours afforded any criterion, it would probably have survived in the dry state for a considerably longer period. Further experiments along similar lines on the various members of the genus would probably throw much interesting light on their habits.

(c) *Description: Galaxias cleaveri, sp. nov.*

General form, moderately stout, subcylindrical.

Depth of body (14.2 mm.), 8.4 in total length (119 mm.), or 7.6 in standard length (108 mm.). Length of head (17.5 mm.), 6.2 in standard length. Eye small, its diameter (2.5 mm.) 8.8 in length of head, or 2.0 in length of snout (5 mm.), or 2.4 in interorbital width (7 mm.). Teeth in the jaws subequal, except for one enlarged lateral canine in each side of lower jaw. Lower jaw projecting; maxillary extending to below anterior third of eye. Branchiostegals, 9.

Dorsal III + 8; the length to its origin (76 mm.) 4.0 times length to origin of pectoral (19 mm.), or 2.1 times space between base of pectoral and origin of ventral (37 mm.): distance from origin of dorsal to end of caudal peduncle (82 mm.) 3.7 in total length: length of base of dorsal (14 mm.) twice interocular distance, or nearly equal to greatest depth of body. When laid back, dorsal reaches beyond superior procurent caudal rays, but only to level of inferior procurent caudal rays.

Anal III + 7; its origin (82 mm. behind snout) behind the origin of dorsal by 1.2 times length of snout, or by 0.75 of depth of caudal peduncle; its base (13 mm.) 1.08 times base of dorsal. When laid back, anal reaches about

to middle of inferior length of caudal peduncle, and extends behind laid-back dorsal by a distance equal to length of snout.

Pectoral with 14 rays; its length (11 mm.) 0.6 of length of head, or 2.2 times length of snout; extending 0.3 of the distance from its base to base of ventral.

Ventrals 6-rayed; their origin (56 mm. behind snout) about equidistant from anterior margin of eye and base of caudal, or about equidistant from base of pectoral and posterior sixth of base of anal; their length (8.5 mm.) rather less than half length of head, or 2.2 in distance between their origin and origin of anal.

Caudal with 22 major rays; rounded subtruncate, its most posterior point being (in alcohol-specimen) 3.6 mm. (i.e., rather more than half distance from tip of snout to posterior margin of eye) behind the vertical joining its postero-superior and postero-inferior angles. Superior procurent rays of caudal begin 1.5 mm. behind base of dorsal, or 91.5 mm. behind snout; inferior procurent rays begin immediately at distal end of base of anal, with which they are just continuous, or 95 mm. behind snout. Hence superior length of caudal peduncle (16.5 mm.) is 2.1 times depth of caudal peduncle, or 1.3 times length of base of anal, while inferior length (13 mm.) is 1.6 times depth of caudal peduncle, or equal to base of anal.

In life, general colour olivaceous, subtranslucent; under-surface in advance of ventrals greyish, behind ventrals greyish-green, immaculate. Snout dark-brown; rest of head, except ventral surface, which is greenish-yellow minutely and sparsely dotted with brown, is heavily blotched with brown, especially dorsally. Sides of body heavily barred and blotched with dark-brown; bars about 22, irregular, but tending to form forwardly directed chevrons with apex near midlateral line, bases of bars with irregular prolongations giving a somewhat reticulated effect, bars about equal in width to their interspaces; between and below bars some irregular blotches. Dorsal surface like lateral surface, but with more brown, the bars showing marked tendency towards confluence. Pectorals light greenish-grey, darker in proximal third. Dorsal, anal, and ventrals greyish or yellowish green, darker in proximal half or more. Caudal greenish, with dark spot at base. In the preserved specimen the ground colour has become opaque, and more yellowish olivaceous.

*(d) Remarks.*

The present species is distinguished from all the described Australian species in having the caudal rounded subtruncate. In general appearance, though not in size, it perhaps more closely approaches the South African *G. zebratus* than any other species; but apart from the improbability, on the grounds of distribution, of it being conspecific with this form, it is readily distinguishable from it by such characters as presence of enlarged lateral canines, much more backwardly placed dorsal, smaller pectorals, shorter head, &c.

It differs from all the Australian species, except *G. dissimilis*, in having 6-rayed ventrals. From *G. dissimilis*, the first published figure of which anomalous form has just been made available by Whitley (1933, Pl. xii, Fig. 2), it is at once separated by the normal, more forward position of the ventrals, size of the pectoral, character of teeth, &c.

In general form and in colouration it closely approaches *G. weedoni*. From this species it is distinguished chiefly by the rounded subtruncate caudal, different number of rays in the dorsal, anal, and ventral, shorter pectoral and ventral, projecting lower jaw, and smaller eye.

The extremely small size of the eye, the diameter of which is 8.8 in the length of the head, is remarkable: the average value of this ratio for the Australian species is about 4.7, the maximum (*G. affinis*) 5.5. According to Tate Regan (1906), the value for *Neochanna apoda* is 6.8. To what extent, if at all, the minute size of the eye might be correlated with the individual history of the specimen, it is difficult to say.

The ventrals are relatively small. The length of these is not regularly recorded in specific diagnoses: judging from figures, however, it would seem that their length is seldom, if ever, contained in the total length more than about 12 times, the average value being apparently about 9.5. In the present specimen this value is 14. Again, it is difficult to determine the likelihood of this being an individual character.

While it is with some diffidence that I venture to create, on the strength of a single specimen, a new species in a family so variable as the Galaxiidae, this seems to be, on the available evidence, the only honest course, and is accordingly followed.

The species is named in honour of Mr. F. Cleaver, West Ulverstone, the collector of the specimen.

Described and figured from the unique holotype in the collection of the Queen Victoria Museum, Launceston, Tasmania; Reg. No. 938 HT.

Suggested vernacular name, Cleaver's Jollytail.

Family AGROSTICHTHYIDÆ.

Genus AGROSTICHTHYS Phillipps, 1924.

*Agrostichthys* Phillipps, Proc. Zool. Soc., Lond., 1924, II., p. 539. Haplotype, *Regalecus parkeri* Benham.

AGROSTICHTHYS BENHAMI, sp. nov.

[Plates VII. and VIII.; Text Figure 2.]

(a) Description.

General form very elongate, and very compressed; ribbon-like.

Greatest depth of body (17.5 mm.), which is immediately behind head, 46.3 in total length (811 mm.), or 46.2 in standard length (808 mm.). Depth at vent (14 mm.) 57.9 in total length. Thickness at greatest depth (6.6 mm.) 2.7, at vent (5.2 mm.) 3.4, and at distal end of body (0.9 mm.) 19.4 in greatest depth. Length of head (38.5 mm.) 21.1 in total length, or almost twice height of head (19.3 mm.). Eye large, its horizontal diameter (9.5 mm.) 1.7 in length of snout (16.2 mm.), which is 2.4 in length of head; about 1.5 times as far from maxillary plate as from dorsal profile of head. Preanal region (252 mm.) 3.2 in total length.

Upper profile of head gently and evenly convex. Actual length of maxillary plate (12 mm.) 1.6 times its actual width (7.6 mm.), but its horizontal extent (11.4 mm.) 1.2 times its vertical extent (9.3 mm.); plate with conspicuous striæ, those on anterior half forwardly concave, those on posterior half backwardly concave, the two sets divided in their superior third by a vertical subtriangular pit, and, behind it, a backwardly concave sulcus. Similar striæ on operculum, radiating from antero-superior angle; on suboperculum, radiating from antero-superior angle; on preoperculum, becoming distinct near the middle from a median sulcus that occupies most of the narrow anterior half or more, and fanning out distally; on interoperculum, running backwards and somewhat downwards.

Dorsal III (?) + c. 400. Three long, pale golden rays in crest-like nuchal section of dorsal; first 108 mm. long (i.e., 2.8 times head, or 2.3 in preanal region), second 70 mm., third 102 mm.; with nodes, placed irregularly (at least, in preserved specimen), clustered round with minute brownish pigment-spots, 3 nodes being traceable on first ray, 7 on second (where pigmented regions about equal their interspaces), 2 on third. As it is possible some of these filaments may be lost, the number is queried: I can, however, find no definite indication of the previous presence of others. In second section of dorsal there are 374 rays up to within 35 mm. of posterior end of body, beyond which point actual count is impracticable: calculation gives 401 as total. Rays to level of vent, 103. Membrane reaches to tip of rays, longest of which is 11 mm. Rays with small spine at base, and with a single linear series of 20-30 microscopic spines, on button-like supports, along each of the two flattened surfaces.

Pectoral with 8 rays; length 9 mm.; supported on basal lobe 3 mm. long, less than 1 mm. high.

Ventrals represented by two very low ridges, about 5 mm. long, contiguous and flush with body in front, diverging and rising behind to end in two subtriangular knobs, directed downwards and outwards; each knob, 1.25 mm. high, with two spine-like projections, of which the antero-internal is the larger. Knobs 5.5 mm. behind level of posterior end of base of pectoral. By moving the ridges, one or two longitudinal slits are disclosed at the base of their external walls. The specimen affords no evidence as to whether the knobs ever bore long rays, like those of *Regalecus*; nor, if so, how many.

The body of the specimen ends posteriorly in a vertical line, 1.7 mm. high, from both the superior and inferior ends of which runs back a free filiform process 3 mm. long. It is difficult to determine from the specimen whether, on the one hand, the extreme tip of the body is damaged, the threads being merely remnants of the body-wall, or whether, on the other hand, the body is intact, the threads relating to the caudal fin: the latter alternative, though not definitely established, has for convenience been selected in determining the length of the fish.

Lateral line appears externally as a ridge, more or less semicircular in section. Originates behind postero-superior angle of operculum; swings down, touching tip of longest ray

of pectoral, in a gentle, forwardly convex curve, to a point 40 mm. behind head, and below 28th ray of major section of dorsal, where it is 2 mm. above ventral margin of body; thereafter extends caudad virtually parallel with, but actually imperceptibly and continuously approximating to, ventral margin, its distance from which, at a point 25 mm. from posterior end of body, is 0.75 mm.; hence average distance of horizontal portion of lateral line from ventral margin is about 1/6th depth of body.

Near anterior end of each lower jaw, two small, closely opposed, conical teeth, directed backwardly; no teeth in upper jaw; a single elegant median vomerine tooth, about 2.5 mm. long, with five cusps, central cusp longest, directed somewhat backwards from the plane of the two pairs of lateral cusps, the proximal pair of which is the larger; beside and behind the median vomerine tooth, one delicate simple conical tooth, on each side. (See Text Fig. 2.)

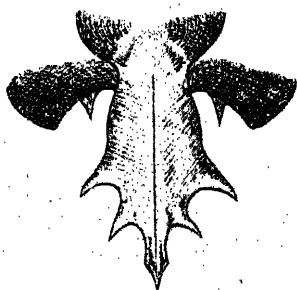


Fig. 2. *Agrostichthys benhami*, sp. nov.: The Vomerine Teeth.  
(About twelve times natural size.)

Mouth protractile to rather more than 1/5th length of head.

General colour (in formalin) greenish silver; body marked by faint dingy vertical bands, averaging 10 mm. wide and 40 mm. apart, formed by sparsely sprinkled brown pigment-cells; similar pigment-spots occur along whole superior margin of body. Head greenish; upper and lower lips narrowly margined with dark-brown; narrow bar of dark-brown behind, and parallel with, maxillary plate, continuous over dorsal surface of head with its fellow on the other cheek; some dark-brown elsewhere on top of head. Iris black, minutely but abundantly speckled with pale-green; pupil

green. Membrane of dorsal fin colourless, with occasional irregular patches of dingy-orange. Pectoral fin pale-green.

Scaless. Body everywhere covered with subcircular cushion-like structures, 0.6-0.9 mm. across, interspaces 0.1-0.3 mm.

It is with pleasure I associate with the present species the name of Professor W. B. Benham, whose description of his *Regalecus parkeri* provides the first account of a representative of the interesting family Agrostichthyidae.

Described and figured from the unique holotype, from Ulverstone, North-West Coast, Tasmania, in the collection of the Queen Victoria Museum, Launceston, Tasmania (Reg. No. 906 HT).

Suggested vernacular name, Benham's Streamer-Fish.

(b) General Remarks.

Benham's type of his *Regalecus parkeri* was washed ashore in Deborah Bay, near Port Chalmers, in Otago Harbour, New Zealand, in or about November, 1902. In an addendum to his paper, Benham (1904) noted the capture at Stewart Island of a second example, 75 inches long. Phillipps (1924) recorded a specimen, approximately 9 feet long, secured at Island Bay, Wellington, New Zealand, in July, 1921. No other records have come under my notice. According to McCulloch (1929) and Whitley (1933), the genus *Agrostichthys* has not hitherto been recorded for Australia. The specimen here described was obtained at Ulverstone, North-West Coast, Tasmania, by Mr. H. G. K. Wells, and was donated to the Museum on 14th February, 1908.

The creation by Phillips of a new genus, *Agrostichthys*, and a new family, Agrostichthyidae, for Benham's *Regalecus parkeri* marks an important step towards a satisfactory arrangement of the Australasian Allotriognathi. Genus *Agrostichthys* Phillipps, 1924; "Body enormously elongated to 22½ times length of head; nearly 42 times greatest depth and 45 times depth at vent; 390 to 525 dorsal fin rays; teeth on head of vomer and on lower jaw; ventral reduced to a single filament or marked by a minute depression if absent. Operculum extended downwards and backwards with suboperculum below it; maxillary plate longer than deep; upper profile of head slightly convex; mouth protractile to ¼ length of head." A key for the differentiation of the families Trachypteridae, Regalecidae, and Agrostichthyidae,

formulated by Phillipps (p. 539), has been improved, and extended to cover the family Lophotidae by Whitley (p. 78), who has also revised the Australian and New Zealand Ribbon-Fishes, of which he admits only four species, namely, *Trachipterus arawatae* Clarke, *Regalecus pacificus* Haast, *Agrostichthys parkeri* (Benham), and *Regilophotes güntheri* (Johnston).

(c) *Comparison of A. parkeri and A. benhami.*

A comparison between Benham's type of his *Regalecus parkeri*, as described and figured, and the present specimen reveals the following differences.

In *A. parkeri* the lateral line comes into virtual parallelism with the ventral border of the body at "about 1½ in. (28 mm.) behind the head," i.e., a little more than half (0.53) the length of the head (53 mm.) behind the head, and, judging from the figure (pl. ix), about below the 11th ray of the main portion of the dorsal. In *A. benhami* the corresponding point is 40 mm., i.e., rather more than (1.04 times) the length of the head (38.5 mm.) behind the head, and is below the 27th ray.

In *A. parkeri* the greatest depth of body is at the vent. In *A. benhami* it is immediately behind the head, and the depth at the vent is only 80 per cent. of the greatest depth, the falling-off behind the nuchal region being quite striking, even on casual examination. It may be observed that in his diagnosis of the genus Phillipps gives the depth at the vent as being about 93 per cent. of the greatest depth of the body; and speaks of his specimen as being "2½ in. high along the greater part of the anterior portion of the body."

In *A. parkeri* the ventrals are represented by "a pair of minute knobs just behind the level of the pectorals on the throat." If Benham's figure is trustworthy, "just behind the level of the pectorals" is to be interpreted as "just behind the level of the beginning of the base of the pectorals." In *A. benhami* the knobs are wholly behind the base of the pectoral by a distance 1.6 times distance of base of pectoral from ventral border of body.

In *A. parkeri* the crest-like nuchal portion of the dorsal comprises 7 rays; in *A. benhami* apparently only 3.

In *A. parkeri* the pectoral has 10 rays, in *A. benhami*, 8. I can in no way reconcile the large barrel-like lobe, intersecting the lateral line, and surmounted by short terminal rays,



as figured by Benhami, with the delicate acuminate pectoral, supported on a small basal lobe, of the present specimen, which, however, is closely approached by that in Phillipps' photograph.

In *A. parkeri* there is "on the palate a small median tooth." In *A. benhami* there are one median and a pair of much smaller lateral vomerine teeth.

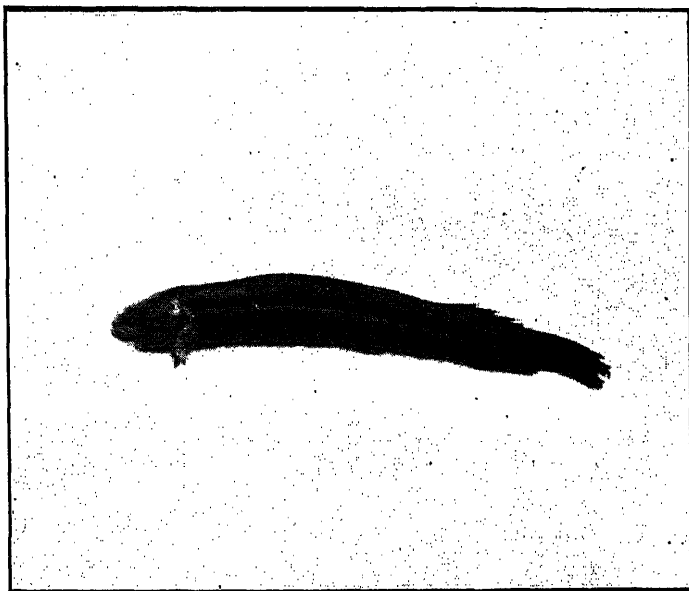
In *A. parkeri* the iris has a black border enclosing a vertical oval silver region. In *A. benhami* it appears to be wholly black, speckled with green.

Minor points of difference, as judged from Benham's plate, include: (a) distance of eye from maxillary, expressed in terms of distance of eye from dorsal profile of head, is about twice as great in *A. parkeri* as in *A. benhami*; (b) posterior border of maxillary, which is shown as being backwardly convex in *A. parkeri*, is backwardly concave in *A. benhami*, in which latter, also, the postero-inferior section of the border is more nearly rectilinear; (c) some differences in arrangement of striæ on maxillary and operculum; (d) the depression extending forward in front of the upper fourth of eye is narrowly subtriangular in *A. parkeri*, broadly oval in *A. benhami*.

The data relating to Phillipps' specimen are too few and indefinite to permit of a detailed comparison being made between it and the present specimen.

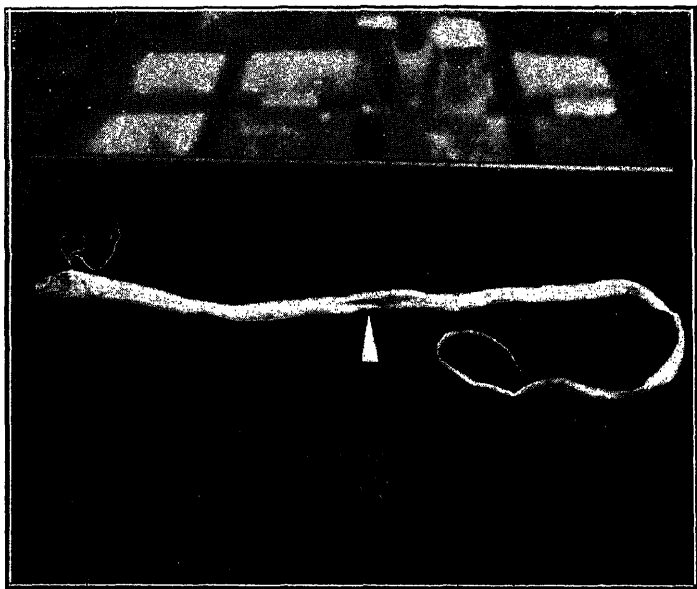
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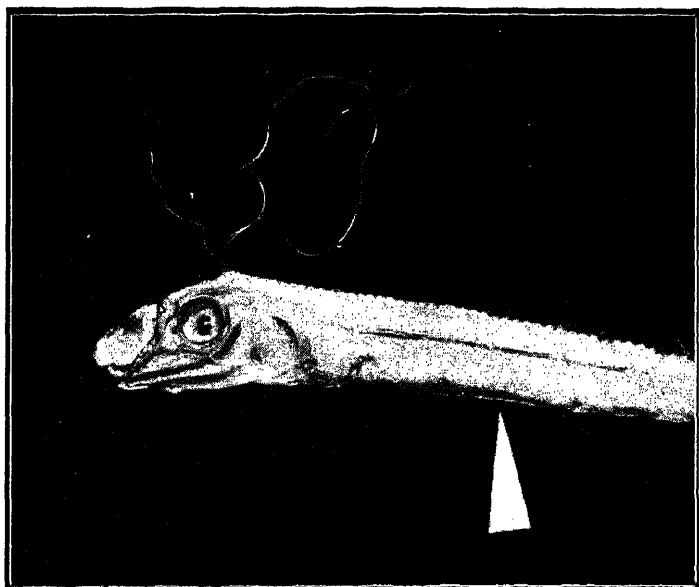
[Burrows Photo.]





[Burrows Photo.]





[Burrows Photo.]



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## EXPLANATION OF PLATES.

PLATE VI.—*Galaxias cleaveri*, sp. nov. Holotype. About natural size.

PLATE VII.—*Agrostichthys benhami*, sp. nov. Holotype; total length 811 mm. The arrow-head marks the position of the vent.

PLATE VIII.—*Agrostichthys benhami*, sp. nov. Anterior end of holotype, slightly enlarged. The arrow-head marks the point at which the lateral line comes into virtual parallelism with the ventral margin of the body.



## A NOTE ON THE SO-CALLED MINUTE SNAKE OF TASMANIA.

By

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Assistant-Curator, Queen Victoria Museum, Launceston.

(Read 25th September, 1933.)

There is throughout Tasmania a deeply-rooted belief in the existence in the island of a distinct species of snake, of small size, the "Minute Snake." While it is perhaps usually taken for granted among naturalists that the supposed Minute Snake is simply the young of one of our three duly accredited species, this explanation does not seem to be adequately established by any precise published data, and is, in my experience, almost invariably contested stoutly by bush-dwellers.

The collection of definite evidence on the subject is a matter of surprising difficulty. Time and time again have I been earnestly assured of the specific distinctness of the form in question; but in spite of repeated efforts, encouraged by not a few promises of assistance, it is only during the present year that I have been fortunate enough personally to examine any small snake that has been claimed to be the elusive Minute Snake. In the circumstances, it seems advisable to put on record a note on the result of the examination of two such specimens.

*Specimen No. 1.*—Received alive at the Museum (Reg. No. 1098) on 30th June, 1933; forwarded by Mr. J. H. White, "Ullapool," Winkleigh, who at my request kindly interested himself in the acquisition of evidence on the matter, and who says of the specimen in a covering letter, "I think it is what we call the Minute Snake." The specimen is a young, but typical, example of *Denisonia coronoides*. Total length, 233 mm.; tail, 43 mm. Dorsal surface olivaceous brown throughout. Ventral surface of head yellowish-grey, spotted with white and dark-brown. Ventral surface of body and tail in general light-orange, tending anteriorly towards yellow, posteriorly towards salmon-pink. Black

streak on side of head, passing through eye, but not continued across rostral; below it, bordering the upper lip, a yellowish-white streak. Scales in 15 rows; longitudinally striated. Ventrals 147, subcaudals (in single row) 55; anal entire. Head-shields fully conformable with specific diagnosis of Boulenger (1896).

*Specimen No. 2.*—Received alive at the Museum (Reg. No. 1099) on 7th July, 1938; forwarded by Hon. H. A. Nichols, M.L.C., of Ulverstone, who in a covering letter states, "This small but lively snake was caught at Preston recently. I think it is a young whipsnake. Some at Preston think it a new species, called 'minute snake.'" Mr. Nichols' identification is correct; the specimen is a young *Denisonia coronoides*. Total length, 180 mm.; tail, 30 mm. Dorsal surface, viewed with naked eye, dull, slightly olivaceous brown throughout; examination with a lens shows the basal half, or rather more, of each scale bears numerous small isabelline spots. Ventral surface of head dark slate-grey, minutely dotted with whitish. Ventral surface of body and tail yellowish-orange, crossed at bases of scutes by dark-brown transverse bars, best marked anteriorly, obsolescent towards tail. Black streak on side of head, passing through eye, but not continued across rostral; below it, bordering the upper lip, and continued backward along side of body for a distance rather greater than the length of the head, a whitish streak, sparsely speckled with dark-brown. Scales in 15 rows; longitudinally striated. Ventrals 147; subcaudals (in single row) 45; anal entire. Head-shields fully conformable with specific diagnosis of Boulenger (1896).

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TASMANIAN AMPHIBIA IN THE MUSEUM OF  
COMPARATIVE ZOOLOGY, CAMBRIDGE,  
MASSACHUSETTS.

By

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Comparative Zoology, Cambridge, Mass., U.S.A.

(Read 25th September, 1933.)

INTRODUCTION.

Though there are represented in the collections of the Museum of Comparative Zoology all of the 19 genera and 75 of the 85 valid species, or races, of Australian amphibia, no Tasmanian material has been received until this year. Recently, through the generous co-operation of Mr. E. O. G. Scott and others, we have been able to complete our collection with all the nine species known to be found in Tasmania.

It will be recollected that on various occasions several species normally occurring on the Australian continent have been attributed to Tasmania. Prominent among these are:

*Hyla peronii* (Tschudi) and

*Limnodynastes peronii peronii* (Duméril and Bibron)

both of the records resting on a single individual of its species, presented to the British Museum by Sir A. Smith prior to 1858. In view of the fact that no others have been taken during the past three-quarters of a century, and taking into account the numerous instances of Sir A. Smith having inaccurate locality data on his specimens,\* it seems reasonable to drop *Hyla peronii* and *Limnodynastes p. peronii* from the Tasmanian list until such time as they may be proved to actually occur upon the island.

Two others, viz., *Hyla krefftii* Günther and *Hyla calliscolis* Peters, have been correctly recorded from Tasmania, but for reasons explained elsewhere I consider both these species synonymous with *Hyla jervisiensis* Duméril and Bibron, a tree frog which is abundant at Launceston.

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\* Such as *Agama calaticeps* Smith and *Pholeophilus capensis* Smith, described as from South Africa, though in reality from Australia, being synonyms of *Amphibolurus diemenis* (Gray) and *Riopa lineata* (Gray).

Of the nine species known to occur in Tasmania, only one—*Crinia tasmaniensis* (Günther)—is restricted to the island. It seems probable, however, that the typical forms of *Crinia lævis* (Günther) and *Hyla ewingii* Duméril and Bibron may be found to be similarly confined, their places being taken upon the continent by subspecies. Unfortunately much confusion exists as to the status of some of these mainland races.

I should like to take this opportunity of expressing my indebtedness to Dr. F. N. Blanchard, of the University of Michigan, for lending and donating specimens; to Mr. Clive E. Lord, for putting me in touch with the Queen Victoria Museum; and finally to Mr. E. O. G. Scott, for his exceeding kindness in procuring material through the co-operation of the schools. In the following pages I have given Mr. Scott's name as collector, and though all the material available to me is listed, some of it has been returned, named, to the Queen Victoria Museum. I am also under deep obligation to Mr. Scott for seeing these notes through the press, which was impossible for me to do at this distance.

#### A KEY TO AID IN THE IDENTIFICATION OF TASMANIAN AMPHIBIA.

- |  |   |                        |
|--|---|------------------------|
| Toes not extensively webbed, their tips not dilated into small disks .....                                     | 1 |                        |
| Toes extensively webbed, their tips dilated to form small disks .....  | 6 |                        |
| 1. Vomerine teeth in a strongly-developed, transverse series behind the choanæ; belly usually immaculate ..... | 2 |                        |
| Vomerine teeth absent or indistinct; belly heavily marbled or mottled .....                                    | 3 |                        |
| 2. Inner metatarsal tubercle longer than the free portion of the adjacent inner toe....                        |   | <i>L. d. dorsalis</i>  |
| Inner metatarsal tubercle much shorter than the free portion of the adjacent inner toe .....                   |   | <i>L. tasmaniensis</i> |
| 3. Inner toe of the forward-pressed hind limb extends beyond the end of the snout .....                        |   | <i>C. s. signifera</i> |
| Inner toe of the forward-pressed hind limb does not extend beyond the end of the snout .....                   | 4 |                        |

A KEY TO AID IN THE IDENTIFICATION OF TASMANIAN  
AMPHIBIA—*continued*.

4. An inner (sometimes indistinct) but no outer metatarsal tubercle; belly smooth *C. l. lævis*  
An inner and also an outer metatarsal tubercle ..... 5
5. Back and belly smooth; hind aspects of thighs usually uniformly dark, sometimes mottled ..... *C. tasmaniensis*  
Back slightly warty, belly areolate or granular; hinder aspect of thighs distally with a large orange patch ..... *P. bibronii*
6. Fingers free of web; digital disks extremely small ..... *H. aurea*  
Fingers webbed; digital disks moderately dilated ..... 7
7. Hinder side of thighs red; size smaller *H. e. ewingii*  
Hinder side of thighs yellow; size larger *H. jervisiensis*

- 
1. Tooth-like ridges on the anterior roof of the mouth.
  2. Internal openings of the nostrils on the anterior roof of the mouth.
  3. A nodular or ridge-like swelling on the sole close to the base of the inner toe.

CERATOPHRYIDÆ.

The South American genus *Ceratophrys* of Boie, 1825, must take precedence over *Leptodactylus* of Fitzinger, 1826, as the type genus for the family called *Cystignathidæ* by Boulenger in 1882, being based on *Cystignathus* of Wagler, 1830. The genus *Pseudophryne* of Fitzinger, 1843, placed by Boulenger in the *Buфонidæ*, is now considered one of the *Ceratophryidæ*.

*Limnodynastes dorsalis dorsalis* (Gray).

*Cystignathus dorsalis* Gray, 1841, in Grey's Journ. Exped. West. Australia, p. 446: Western Australia.

♀ (M.C.Z. 19258) Eaglehawk Neck, T. (F. N. Blanchard), 1928.

♂ (M.C.Z. 19330) Tasmania (T. M. S. English), 1901-1903.

♀ (M.C.Z. 19371) Stanley, T. (E. O. G. Scott), 1933.

Trinomials must be used for this species, since Fry (1913, p. 23) defined several "varieties" which are in reality good geographical races. Three of the four races are represented in the Museum of Comparative Zoology. The typical form is distinguished from all the others by its smooth back.

English (1910, p. 629) states that he caught only one of these frogs, but Mr. E. O. G. Scott assures me that there is a second specimen collected by English on exhibition in the Queen Victoria Museum. Our specimens measure: ♂ 58 mm., ♀ 60 mm.

*Limnodynastes tasmaniensis* Günther.

*Limnodynastes tasmaniensis* Günther, 1858, Cat. Batr. Sal. Brit. Mus., p. 33, Pl. ii, Fig. B: Tasmania.

- 1 (M.C.Z. 19333) Launceston, T. (E. O. G. Scott), 1933.

Both Fletcher (1897, p. 662) and English (1910, p. 628) record this species from Launceston, where it is common. I have compared it with examples from Victoria and from Eidsvold, Queensland. Our specimen is immature, measuring 31 mm. from snout to anus.

*Crinia signifera signifera* (Girard).

*Ranidella signifera* Girard, 1853, Proc. Acad. Nat. Sci. Philad., 6, pp. 421-422: Australia.

- 1 (M.C.Z. 19225) Near National Park, T. (F. N. Blanchard, 1928).

- 1 (M.C.Z. 19334) Launceston, T. (E. O. G. Scott), 1933.

Trinomials are employed, as the Western Australian race, *C. s. ignita* Cope, of which *C. stolata* Cope is a synonym, is distinguished by its larger size and the absence of dark blotches or marbling on the under-surface. *C. s. signifera* of the east and south is smaller, and has these dark marblings, except in very young individuals. Through the courtesy of the Director of the Philadelphia Academy and the co-operation of Dr. E. R. Dunn, I have been able to examine the types of *signifera*, *ignita*, and *stolata*. Our specimen from Launceston is somewhat dried; it measures 18 mm.

*Crinia tasmaniensis* (Günther).

*Pterophrynus tasmaniensis* Günther, 1864, Proc. Zool. Soc., London, p. 48, Pl. vii., Fig. 3: Tasmania.

- 10 (M.C.Z. 19240-9) Cradle Valley, T. (F. N. Blanchard), 1928.

This is the species over which so much printers' ink has needlessly been expended, when, as Blanchard (1929, p. 324) has pointed out, correctly identified specimens from Mt. Wellington and Hobart, collected by Professor E. J. Goddard so long ago as 1909, were in the Australian Museum. Dr. F. N. Blanchard secured good series at Lake Fenton and other localities, his being the first records in the literature since the species was described 64 years earlier. ♂, 17 mm., ♀, 30 mm.

*Crinia lævis lævis* (Günther).

*Pterophrynus lævis* Günther, 1864, Proc. Zool. Soc., London, p. 48, Pl. vii., Fig. 4: Tasmania.

- 6 (M.C.Z. 19226-31) Wilmot, T. (F. N. Blanchard), 1928.  
1 (M.C.Z. 19331) Tasmania (T. M. S. English), 1901-1903.  
1 (M.C.Z. 19335) Dunorlan, T. (E. O. G. Scott), 1933.

Fletcher (1898, p. 663) later came to regard his *Crinia froggati* as no more than a "variety" of *lævis*; they are undoubtedly very closely related, and it may be that *froggati*, which was described from Buninyong, near Ballarat, Victoria, is the mainland representative of *lævis*. Blanchard (1929, p. 328), however, may be correct in treating *froggati* as a full species. The Dunorlan specimen, taken between March 17 and April 11, is not breeding, whereas the Wilmot series, taken on March 7, are gravid; see also Blanchard (1929, p. 327), who figures the spawn.

*Pseudophryne bibronii* Steindachner.

*Pseudophryne bibronii* Steindachner, 1867, Reise Osterr. Freg. Novara. Amphib., p. 34, Pl. v., Figs. 1 and 2: Australia and Tasmania.

- 4 (M.C.Z. 19336-8) St. Patrick's River, T. (E. O. G. Scott), 1933.

These have been compared with specimens from Sydney, New South Wales, from which they do not appear to be separable. All the examples of both sexes have the ventral marbling extending on to the throat, though the tip of the chin may be free from marbling. In *P. semimarmorata* Lucas, on the other hand, the marbling does not extend on to the throat, which is white in females, dark or dusky in males. The Museum of Comparative Zoology possesses over a hundred examples of *P. semimarmorata* from localities on Mt. Kosciusko, quite close to the type locality in North Gippsland, Victoria. I cannot, therefore, agree with Fletcher (1897, p. 665) in considering these Tasmanian examples of *bibronii* as *semimarmorata*. Of course it is possible, though improbable, that his material from Ulverstone and Launceston does represent *semimarmorata*, for I have seen no examples from these localities. Unfortunately our Tasmanian specimens are somewhat shrivelled, through being placed in too strong alcohol; the largest measures 27 mm. from snout to anus.

## HYLIDÆ.

*Hyla ewingii ewingii* Duméril and Bibron.

*Hyla ewingii* Duméril and Bibron, 1841, *Erpét. Gén.*, 8, p. 597: Tasmania.

- 1 (M.C.Z. 19252) National Park, T. (F. N. Blanchard), 1928.
- 7 (M.C.Z. 19358-62) St. Patrick's River, T. (E. O. G. Scott), 1933.
- 14 (M.C.Z. 19363-9) Dunorlan, T. (E. O. G. Scott), 1933.

The outer finger usually with the merest rudiment of web, at most only a quarter webbed; outer toe webbed to base of disk or a little short of the disk; median digital disks as large as, or slightly smaller than, the tympanum; the tibio-tarsal articulation of the adpressed hind limb marks the orbit or (more usually) just beyond; skin of back smooth (in formalin) or with very small, pimple-like warts (in alcohol). Above, grey, forehead to interorbital region lighter, a more or less well-defined silvery streak from the upper lip to the base of the forearm; a broad brown dorsal streak from the interorbital region to above the anus; hinder side of thighs *uniformly red* (in fresh material), or with a few large spots and streaks on a red ground.

The largest ♂ measures 32 mm.; the largest ♀, 37 mm.



*Hyla jervisiensis* Duméril and Bibron.

*Hyla jervisiensis* Duméril and Bibron, 1841, Erpét. Gén., 8, p. 580: Jervis Bay, New South Wales.

*Hyla krefftii* Günther, 1863, Ann. Mag. Nat. Hist. (3), 11, p. 28, Pl. iv., Fig. C: Sydney, New South Wales.

*Hyla calliscelis* Peters, 1874, Monatsb. Akad. Wiss. Berlin, p. 620: Adelaide, South Australia.

1 (M.C.Z. 19054) Launceston, T. (Australian Mus.), 1938.

63 (M.C.Z. 19339-50) Launceston, T. (E. O. G. Scott), 1938.

3 (M.C.Z. 19351-2) Stanley, T. (E. O. G. Scott), 1938.

6 (M.C.Z. 19353-7) Franklin, T. (E. O. G. Scott), 1938.

Boulenger (1882, p. 383), lacking material of *jervisiensis* as he thought, believed it to be related to *cærulea*. I have good evidence for believing *krefftii* to be a synonym of *jervisiensis*; detailed reasons for this opinion will be given elsewhere (in MS.). On the other hand, Boulenger (1882, p. 407) made *calliscelis* a race of *ewingii*, though he lacked topotypic material of *calliscelis*; his two frogs from King George's Sound, South-Western Australia, may, or may not, have represented *calliscelis*. After comparing a South Australian *calliscelis* with New South Wales *jervisiensis*, I find that they differ in just those characters cited by Fry (1915, p. 84):

"Groin and hinder thigh with accentuated purple blotches .....	<i>calliscelis</i> ."
Groin and thigh yellowish with faint brown speckles .....	<i>krefftii</i> ."

The large series from Launceston and Franklin, however, show both types and every intergradation between them; on the supposition that large series of South Australian or New South Wales specimens would show similar variation, I relegate *calliscelis* to the synonymy of *jervisiensis*, not deeming it worthy of subspecific rank.

This explains why both *krefftii* and *calliscelis* have, in the past, been recorded from Tasmania by various workers.

Unfortunately Fletcher (1897, p. 665) confused several forms, including *calliscelis*, with *ewingii*. In the latter respect he was followed by English (1910, p. 632). Fry (1915, p. 79) cleared away some of the tangle by naming *H. ewingii alpina* from Mt. Kosciusko, New South Wales. Fletcher had called this mountain form *calliscelis*, for it shares with that form the distinction of possessing purple blotches (brown in *calliscelis*?) on a yellow hinder thigh.

Fry, however, thought that the best solution was to retain *calliscelis* as a race of *ewingii*, and make *krefftii* also a race of *ewingii*; actually he called them varieties. On grounds of geographical distribution they cannot be regarded as races, so I treat *jervisiensis* as a full species, while entirely agreeing that it is closely related to the members of the *ewingii* group.

After careful study of this Tasmanian material I have come to the conclusion that the only safe characters available to distinguish the two species occurring in Tasmania are those which I have employed in the preceding key. There are other average differences of webbing, limb-length, &c., which are of assistance when comparative material is available, but they do not serve to make a sharp and distinct separation between *jervisiensis* and *ewingii*.

The largest ♂ measures 38 mm.; the largest ♀, 45 mm.

*Hyla aurea* (Lesson).

*Rana aurea* Lesson, 1830, Voy. Coquille, 2, p. 60, Pl. vii., Fig. 2: Macquarie and Bathurst Rivers, New South Wales.

*Hyla aurea* var. *cyclorhynchus* Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p: 411: West Australia.

♂ (M.C.Z. 19332) Tasmania (T. M. S. English), 1901-1903.

♀ (M.C.Z. 19370) Stanley, T. (E. O. G. Scott), 1933.

Binomials only are used, as our extensive Western Australian material of this species shows considerable variation and little grounds for supposing that *cyclorhynchus* should be recognised as a western race. Boulenger's types may represent extremes of variation or a full species.

Our Tasmanian representatives of the Golden Frog measure: ♂, 50 mm.; ♀, 73 mm.—but are surpassed by continental examples.

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## TASMANIAN CYCADOPHYTA.

[Part 2.]

By

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(Read 11th December, 1933.)

In a former paper, read before the Royal Society on 12th May, 1930, I gave some illustrated notes respecting certain cycad stems recovered from the Miocene strata at Evandale. The status of these specimens was called in question by certain palæobotanists, both in and outside the Australian Commonwealth. By a fortunate discovery a small piece of a trunk was afterwards found that proved beyond all question that they had an organic origin, and were not, as objected, inorganic concretions. This discovery, however, did not extend the microscopical evidence to the concentric woody layers, but related to the intrusts of periderm into the central cavity of the stem, a state of things already found to obtain in cycad trunks from Dakota, U.S.A. In September last a splendid section of a trunk was found in the railway ballast-pit, and through the kindness of Mr. G. Curtis, of the Railway Department, and the keen interest manifested in it by the actual finder—Mr. L. V. Mason—we were enabled to secure this unique specimen. Some 2 feet of the trunk, in three fragments, eventually came to hand, and in many places the structure of the woody rings can be readily studied. As the diameter of the bole is 6 inches by 5 inches, we are evidently in possession of the remains of a fully-grown tree. The finding of this stem sets at rest for ever all objections raised against the organic origin of the specimens, and at the same time supplies us with several connecting links that serve to complete our chain of evidence, as will now be shown.

As the 50 lb. weight of fragments obtained at Evandale suggested both *Cycadites* and *Bennettites*, they were exhibited in the Museum cases as being such—all that manifested concentric layers of wood being relegated to the former taxonomy, and those that showed the entire centre to be

altered parenchyma, without woody structure, to the latter. By far the best stems belonged to *Cycadites*, and in exhibition only one perfect illustration of *Bennettites* was shown (Q. V. M. Pal.-Bot. No. 33), but later on a stem was found at Mulgrave-crescent, Launceston, in which woody periderm ran into the central parenchyma in the form of a latticework. Until the recovery, from the Launceston Miocene strata, of this large woody cycad trunk this specimen (Q. V. M. Pal.-Bot. No. 77) was the only evidence available respecting the intrusting of woody periderm into the central parenchyma. Now, however, the railway ballast-pit section (Q. V. M. Pal.-Bot. No. 66) shows this most perfectly in its lower parts, while the upper areas are completely hollow. Obviously, therefore, this is to be regarded as a growth note, in which the central parenchyma was reinforced at the base of the stem, but the process became unnecessary higher up.

A "developed" section of one of the original specimens that came to hand from Evandale (Q. V. M. Pal.-Bot. No. 31) shows the leaf traces leaving the stem to perfection. The outer surface is heavily scored with the leaf scars, and the fractured surface shows the course of no less than 12 most perfect bundles of leaf traces.

A specimen (Q. V. M. Pal.-Bot. No. 35) has yielded evidence of seeds *in situ* in the strobilus, but so far these are the only ones detected.

Among microscopical details obtained from the railway ballast-pit stem the following were noted:—

- (1) Medullary rays.
- (2) Bordered pits to tracheids.
- (3) Raphides (cubical rather than needle-shaped).
- (4) Good evidence as to the resin ducts.

As this is a mere recapitulation of Museum specimens, very little need be said as to the works of palæobotanical authors, except to again refer to Dr. Marie C. Stopes' (D.Sc., Ph.D.) fine work upon the cretaceous flora, in the British Museum Catalogue series, and the valuable books upon fossil botany by D. H. Scott.

## A CORRELATION OF THE TASMANIAN PLEISTOCENE GLACIAL EPOCHS AND DEPOSITS.

By

A. N. LEWIS, M.C., LL.D., M.H.A.

(Read 11th December, 1933.)

### 1. PRESENT PROGRESS OF INVESTIGATION.

During the past year Sir Edgeworth David did me the honour of asking me to contribute a section to his "Geology of Australia," dealing with the Pleistocene glaciation in Tasmania. In the course of this work I found it highly desirable to affix names to the three glacial phases, the existence of which is now fully established. In the space available in Sir Edgeworth's work, I could do no more than use these names. A purpose of this paper is to record my reasons for the choice.

The widespread range of Pleistocene glacial drifts in Tasmania was recognised by Charles Gould as early as 1860, and by 1885 R. M. Johnston had recorded their existence over the whole of the western highlands (Johnston, 1893). Until 1893 no suggestion had been made that there had been more than one glacial phase in Tasmania, but in the paper last referred to R. M. Johnston recorded difficulties in the interpretation of the field evidence, which have since been used to prove the existence of such separate phases (see *loc. cit.*, p. 100). In this branch of learning, however, I must award the palm for early accurate observation and clear geographical discernment to T. B. Moore. As early as 1895 this outstanding explorer advanced a theory that there had been two glacial epochs during the period under review, and advanced evidence which my later investigations confirm entirely (Moore (1895), p. 76; and see also R.S. of Tas., 1893 and 1894, *sub. nom.* T. B. Moore).

Unfortunately, T. B. Moore's theory was disregarded, and for 25 years various writers on this topic floundered in a maze of their own making. By disregarding the very clear evidence of separate and distinct glaciations, they endeavoured to reconstruct the traces of all into the framework of one ice invasion. The result was contradictions everywhere

and observers contented themselves with recording evidence—the reconstruction of ice movements being fraught with so many apparent difficulties. This fact must be borne in mind when studying the numerous reports of glacial phenomena published prior to 1920.

In 1921 Professor Griffiths Taylor drew attention to the clear evidence of a double glaciation in the National Park (Taylor, 1921), although he missed the true significance of the field evidence he recorded, as had I, in my description of the area published in the same volume. Some time prior to 1922 Dr. Loftus Hills had made certain observations in the vicinity of Strahan. These he showed to Sir Edgeworth David, who confirmed Dr. Hills' theory that here was distinct evidence of at least two glaciations (David, 1926). Dr. Hills made some mention of this to me at the time, but he did not publish or, as far as I know, elaborate his ideas then.\*

In 1922 (December) I was descending the slopes of Mt. Anne, and, looking over the Huon valley—whether the evening light or the peculiar configuration of the Frankland Range emphasised the fact I know not—but I was struck with the absolute clearness, in the panorama there unfolded, of the evidence of two distinct and superimposed glaciations, the one responsible for the topography of the Huon Plains, the other disclosed in the tributary valleys leading down from the encircling ranges. The fact of a smaller series of valley glaciers, terminating in piedmont moraines, each resting on the older glaciated surface of the wide Huon valley, was too apparent to be missed. With this clear disclosure in the field, I found the key to the task of reconstructing the history of the Pleistocene glaciation in this island. I made reference to this idea in 1923, and definitely advanced the evidence on which I based the conclusion that Tasmania had experienced three Pleistocene glacial epochs (Lewis, 1923, p. 32). I then attempted to correlate the Tasmanian glaciations with those of the Northern Hemisphere, an attempt I have now abandoned. In the same year Sir Edgeworth David, after full consultation with all Tasmanian geologists, set his seal to the classification of the Pleistocene glaciations into three easily distinguishable phases (David, 1923).

After further study, the position was crystallised by the Report of the Glacial Sub-Committee of the A.A.A.S.,

\* The distinctions noticed by Moore, Hills, and David were between the Malanna and the Yolande glaciations; those noticed by Taylor were between the Yolande and Margaret glaciations.

Adelaide meeting, 1924, in which I elaborated my previous ideas, and Sir Edgeworth David followed with modifications and confirmation of the general theory. (Lewis, 1926; David, 1926.) Since 1926 little further advance has been made, except in the direction of the collection of further evidence, all of which confirms the conclusions enunciated in the report referred to lastly above.

## 2. NOMENCLATURE ASSIGNED TO THE SUBDIVISIONS OF THE PLEISTOCENE GLACIATION.

For reasons to be set out hereafter, I have had to reject an absolute correlation between Tasmanian and European glacial epochs. The desirability of local names in cases in which absolute correlation is not absolutely certain is recognised. It is most difficult to fix upon any Tasmanian locality as absolutely typical of any of the glacial phases, as the features of all are so uniform throughout the country. After examining the claims of every recorded area to the title of type locality, I decided that the district in which clear examples of each phase could be found in the smallest compass was that described by Sir Edgeworth David. This area possesses the advantages for such purpose of accessibility and compactness, and has already been thoroughly mapped. Further, it has been described by the greatest authority on the subject, and Tasmania may well pay Sir Edgeworth David the compliment of choosing the area he has described as the type locality for its glacial geography.

For these reasons I selected the following names for the three identified glacial epochs:—

1. Malanna Glaciation: For the earliest, most extensive ice-cap stage of the Pleistocene period.
2. Yolande Glaciation: For the second, cirque cutting and most obvious stage.
3. Margaret Glaciation: For the most recent, or mountain-tarn, stage.

The applicability of this terminology will be appreciated on reference to Sir Edgeworth's description of the area. Nowhere else are the three phases to be seen in such clear juxtaposition within an area of the same size and accessibility.



### 3. THE LATE TERTIARY AND PLEISTOCENE SUCCESSION IN TASMANIA.

The continual sub-aerial conditions, the confusing succession of land movements, and the absence of definite time marks render our period difficult to correlate with the accepted subdivisions of geological time. Indeed, as far as the geology of Tasmania goes, there is no justification for separating Pliocene, Pleistocene, and Recent periods.

At one end there comes the marine limestone of Table Cape and the Tamar basin, probably of Miocene age, with the freshwater leaf beds of the Launceston and Derwent basins, not far removed in point of age. Overlying these is the older olivine basalt, which may be of Miocene or Pliocene age. From the date of the latter rock, itself most uncertain, all is doubtful at present. The succession of the three glacial periods is clear as between themselves, but all search has failed to disclose a starting point for correlating them with the basalts and older tertiary formations, on the one hand, and the raised beach and river terrace deposits of Northern and Eastern Tasmania, which are usually referable to Recent age, on the other hand.

In point of fact, and it is one of my present purposes to stress, the glacial epochs cannot be segregated into a division by themselves and referred to "Pleistocene" age, and the raised beach and terrestrial deposits cannot be separated into another compartment and called "Recent," as has been done heretofore. The two series were probably deposited contemporaneously, but in different parts of the country.

As far as my observations have extended, no clearly defined Malanna glacial deposit or erosion feature stands in juxtaposition to defined tertiary strata or older basalt. We merely presume that the latter are older than any late Tertiary glaciation. This is supported by the balance of probabilities, but by nothing more. The relationship between the older and the newer basalts has not been worked out to such a degree that we can distinguish a given occurrence with certainty. It appears that a very considerable interval of time elapsed between the two eruptions, probably a greater interval than exists between the eruption of the newer basalt and the present day. I was struck by the fact that in the Coal River valley, immediately north of Richmond, newer basalts overlies clays and soils in no way distinguishable from those cultivated to-day in the immediate vicinity.

On the Central Plateau glacial features are superimposed on the newer basalts. But here we observe the faint feather-edge of the glaciation, and it is difficult to distinguish its period with certainty. There is no difficulty in saying that the Yolande glaciation was more recent by a considerable space of time than the eruption of the newer basalts. If my interpretation of the field evidence is correct, the Malanna glaciation is also superimposed over sheets of newer basalts in the vicinity of the Great Lake and elsewhere. But I have not yet established this fact to my complete satisfaction. Nevertheless, the balance of probabilities again points to the fact that the newer basalts preceded the Malanna ice-cap.

Of the boundary, in Tasmania, between the Pliocene and the Pleistocene, or the correlation of the Malanna glacial epoch to this point of time, we know nothing at present. The Wynyard stage, the older basalts, the river drifts and lacustrine deposits, and the newer basalts are distinct in themselves (see Nye and Lewis, 1928, for fuller descriptions), and no doubt exists as to the local succession. But they present a very broken and uncertain record of Tertiary times, and provide no connection with subsequent events.

In these circumstances we cannot date the Malanna ice age. We may accept the general correlation of the Tasmanian ice age with the Pleistocene period. It certainly is far later than the Miocene. Since that period the older basalts were erupted and eroded, great depths of terrestrial deposits accumulated and also eroded, and river systems were invaded by newer basalts at a considerably more recent date. From approximately the date of these flows until relatively modern times Tasmania has been subject, at least in higher altitudes, to more or less glacial conditions. But our real problem is: did our southern phases correspond with those of the Northern Hemisphere, or did they occur alternatively with the glacial and inter-glacial epochs in the Northern Hemisphere, or were they merely approximately contemporaneous without any real inter-connection? The solution of this problem would be Tasmania's greatest contribution to the knowledge of recent glacial phenomena. Unfortunately, an answer is not yet to hand.

It is clear that the Malanna glaciation was the most intense, and it is safe to state that it covered from a third to a half of Tasmania. The many apparent breaks and inconsistencies are due to post-Malanna erosion. It is also clear that the time-interval between the maximum phase of

the Malanna glaciation and that of the Yolande glaciation was far greater—I would say four times greater—than the time-interval between the Yolande glaciation and the present day. The remains of the Malanna glaciation have been largely eroded by the river systems; elsewhere the limits have been submerged under the sea, and the origins have been obliterated by the Yolande glaciation. It is therefore only in a few favoured localities that such evidence persists. It is no wonder that early observers connected these vestiges with the neighbouring Yolande valley glaciers rather than with the distant occurrences, now separated by miles of waterworn valley.

As to the duration of the Malanna glaciation, I can only say that from its extent and remains it appears to have been of far longer duration than the Yolande period. Then came the Malanna-Yolande inter-glacial. This also lasted for a very lengthy period. The Yolande glaciation occurred upon, virtually, our present day physiography; the Malanna glaciation left a physiography which differed so materially from that which we know that it is difficult to reconstruct it. Vast changes occurred during the Malanna-Yolande inter-glacial, and, moreover, obviously required a vast space of time to impart the results which are apparent. The date of the land movements that elevated most of our central plateaux is disputed. I incline to the idea that several sectional uplifts occurred, and that the first, involving the country from the west coast to a line from the Forth River to New River, occurred immediately prior to the Malanna glaciation, and the succeeding uplifts to the east occurred during the Malanna-Yolande inter-glacial. But I do not wish to press this view, as it is not accepted by the Geological Survey.

Nevertheless, this is certain: many rivers—the Pieman, King, Gordon, Huon, Derwent, Ouse, Lake, Mersey, and Forth, to name only the more important—cut gorges from 1000 to 2000 feet deep in the hardest of rocks during the Malanna-Yolande inter-glacial. This is the explanation of the fact that there are widespread Malanna morainal deposits at Strahan and south of Macquarie Harbour, but none in the lower King and Gordon Rivers, down which the ice would naturally flow; and similarly with other rivers. The erosion during the Yolande-Margaret inter-glacial has been inconsiderable, and, making all allowances for the increase in erosion in the lower reaches of rivers fed by Yolande

glaciers, it appears, from the extent of the Malanna-Yolande inter-glacial erosion, that the duration of this inter-glacial period, in itself far exceeded the time from the Yolande glaciation to the present day. Indeed, if the commencement of the Malanna glaciation were to be dated as a million years ago, I would estimate the length of the Malanna-Yolande inter-glacial as 600,000 years, and date the commencement of the Yolande glaciation not earlier than 100,000 years ago. This period would then have lasted for 50,000 years, with an inter-glacial period of about half as long, and the Margaret glaciation commencing about 20,000 years ago and lasting until within 5000 years or less of the present day. I place no reliance on these dates as such, but the relative time-interval represents my view of the proportion of the Pleistocene period occupied by each phase. The Yolande glaciation followed. This is unmistakable. It has been responsible for the moulding of the topography of the altitudes over 2000 feet—and this area is very considerable. It has also been responsible for the more obvious moraines and glacial deposits. It cannot be stated with absolute certainty that there was an absolute inter-glacial period between the Yolande and the Margaret glaciations, but all the evidence points to such occurrence. Certainly the Margaret glaciation was a definite and distinct feature, too universal, persistent, and protracted to be regarded as merely a phase of the recession of the Yolande glaciers. It probably represented a definite onset and waning of glacial conditions, but to a less degree of intensity, both as to level affected and time occupied, than the Yolande glaciation. This phase persisted until very recently. Indeed, it has not yet entirely departed, although permanent ice no longer exists.

Contemporaneously with the ice periods on the highlands and west coast, considerable river and estuarine deposits were accumulated in the lowlands and along the north and east coasts, and raised beaches of indefinite age appeared. Great differences in the flow of the principal rivers and consequent eroding power, due to marked changes of climate, are also apparent. All these are attributable to the same causes as produced the ice-flows further west. It is most apparent that our rivers and creeks have all shrunk in volume in the near past. This is natural considering that most were ice-fed during earlier periods. No attempt has yet been made to correlate the river terraces and raised beaches with the several glaciations, but this should not be impossible. I have to content myself here with stressing

that these deposits, which so largely cover the later basalts through Southern, Eastern, and Northern Tasmania, and fringe these coasts, are largely the results of the glaciation of the elevated country inland, and cannot be separated from the Pleistocene glacial periods. Similarly, it is impossible to differentiate downwards between Pleistocene and Recent strata. "Post-Margaret deposits" appears to be the more accurate term for those which can be differentiated as such.

#### 4. CORRELATION WITH THE NORTHERN HEMISPHERE.

I have described three glacial periods as occurring in Tasmania. These three are distinct, and their occurrences are distinguishable. The general time-relationship, considering Tasmania alone, has been established. My investigations, however, do not preclude the occurrences of other glaciations. Three possibilities exist:—

- (i) A pre-Malanna glaciation, the traces of which have been obliterated by erosion or by the more intense Malanna glaciation.
- (ii) A phase between the Malanna and the Yolande, the evidence of which has been confused with one or other of the identified glaciations or obliterated by the Yolande glaciers.
- (iii) A subdivision of the Malanna glaciation into more than one phase.

I am satisfied that the typical Yolande glaciation cannot be subdivided, and that none occurred between the typical Yolande and the Margaret or after the Margaret phases. As to the other possibilities mentioned above, all I can say is that no evidence exists. But in view of the present state of our knowledge, and the very fragmentary remains of the Malanna glaciation, this does not exclude such possibilities. The point is important. If we have had three glaciations, there would be a temptation to fit them in to the interglacial periods of the Northern Hemisphere. If we have had contemporaneous glaciations with the Northern Hemisphere, we must explain the absence of evidence of the missing one. If it is the earliest that is missing, as I strongly believe, and the Malanna glaciations can be correlated with the Mindel, it is possible that Tasmania escaped the Gunz glaciation owing to the fact that our mountains had not at that time been uplifted to the necessary height. To establish this fact would be to discover a date for the final elevation of our

*horst* plateaux. In any case, I feel that a close study of the earlier phases of the glacial period, and the relationship of river erosion and deposition thereto, will disclose that there also exists a powerful earth-movement factor. It is a purpose of this paper to point out that none of these factors can be understood separately.

In the present state of our knowledge it is impossible to correlate the Tasmanian glacial periods with those of the Northern Hemisphere. It is tempting to connect the Malanna glaciation with the Mindel, the Yolande with the Riss, and the Margaret with the Würm. In my opinion, however, such can be no more than a guess, and may lead to fatal error. For the present, we can only adhere to local terminology and correlation.

#### 5. FUTURE INVESTIGATIONS.

This field is really so lightly touched in essentials that any detailed investigation of the various problems mentioned above would be welcomed. It seems that the Yolande glaciation is our one definite time-mark, and that the work of correlation, both local and world-wide, must start from this base. Thence, the search for a Yolande moraine superimposed on a Malanna moraine must be prosecuted to success. A careful investigation of the edges of the Malanna deposits at Strahan may give a clue as to the succession downwards. It appears at present as if the river terraces or raised beaches of Pleistocene age are nowhere closely associated with glacial deposits, but an investigation of the shore-line between Recherche and Temma should throw sufficient light on this succession to establish a basis for inter-correlation. Failing any such discovery, a close study of the succession of river terraces and their erosion should provide a sequence which can be reasonably correlated with the glacial phases. I am satisfied that the data exist, but up to the present I have not been able to identify a reliable starting-point.

I conclude by expressing the hope that workers interested in Tasmanian glaciation will advance from a mere description of deposits and erosion forms to a logical correlation of the features observed, either to confirm or to contradict the conclusions summarised above.

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# A CONTRIBUTION TO THE STUDY OF TASMANIAN COPEOGNATHA.

By

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Six Text Figures.

(Read 11th December, 1933.)

Probably few Tasmanian insects have been so generally neglected by students as those usually small but plentiful forms which comprise the order Copeognatha or Psocoptera. The Australian and New Zealand species have been studied by MacLachlan, Enderlein, and Tillyard, but the literature contains only isolated references to Tasmanian forms.

Among the species dealt with in the present paper are two archaic forms of more than ordinary interest. One of them closely resembles *Sphæropsocus kinnowi* Hagen, a fossil species found in Baltic amber, whilst the other is a member of the rare and primitive family, Lepidopsocidæ.

## Suborder PARAPSOCIDA Tillyard, 1926.

### Family LEPIDOPSOCIDÆ.

#### Genus *Tasmanopsocus* n.g.

*Diagnosis.*—Head very hairy. Thorax, abdomen, and legs clothed with both scales and hairs. Three ocelli present. Antennæ with 40 joints. Apical joint of maxillary palpi hatchet-shaped. Tibial segments of the legs armed with long powerful spines, as in the genus *Echinopsocus* Enderlein. Tarsi three-jointed. Forewings bluntly pointed and short, reaching only to the middle of the abdomen. The venation is not constant, but the arrangement of the veins as shown in Fig. 2 B holds good in most specimens of the genotype. Sc is not fused with R. The radial sector (Rs), which is unbranched, leaves R near the middle. M is fused with Cu<sub>1</sub> towards the base. Both M and Cu<sub>1</sub> are branched dichotomously. Cu<sub>2</sub> is absent. In the wings of some specimens 1A fades out towards the base. In other cases it is well developed and occasionally branched. As in the genus *Echmepteryx* Aaron, there is no distinct pterostigma. The



wings are clothed with hairs, coarse bristles, and striated, cultriform scales. The coarse bristles are minutely barbed. They occur along the veins and in the costal, anal, and apical regions of the wing. Each bristle rises from a cup-like socket. (Fig. 2 H).

The hindwings are minute, membranous, scale-like vestiges not extending beyond the metathorax.

*Genotype*.—*Tasmanopsocus litoralis* n.s.

*Habitat*.—Southern Tasmania.

*Tasmanopsocus litoralis* n.s.

Female.—Length of body, 2.9 mm.; length of forewings, 1.2 mm.; length of antennæ, 2.4 mm.

*Colour*.—Body light-brown, with a silky sheen, due to the presence of scales. Epicranium and frons marked with a dark-brown pattern, as shown in Fig. 2 A. Clypeus, clypeolus, labrum, and genæ dark-brown, almost black. Distal joint of maxillary palpi dark-brown, other joints light-brown. Antennæ light-brown. Femora dark-brown. Tibiæ light-brown, encircled with two broad dark-brown rings (Fig. 1 A). Tarsi light-brown, becoming darker towards the base. Abdomen light-brown, with a darker median longitudinal band on the dorsal side.

*Head* large and triangular. Surface very hairy. Paired eyes, finely pubescent, 0.34 mm. in diameter, composed of numerous ommatidia, and occupying the posterior angles of the head. Epicranial and frontal sutures well marked. Three small ocelli present and somewhat widely spaced. Antennæ long and slender, consisting of 40 segments, which are subequal in length. From the third outwards the segments possess minute hairs, arranged in a series of rings, and a whorl of four long slender spines. (Fig. 1 E). Maxillary palpi, four-jointed. The apical joint is hatchet-shaped, slightly longer than the second joint, and provided with a number of sensory pits. The second joint has a small dentiform spine on the inner side near the base (Fig. 2 A). All the joints are clothed with fine hair. Styliform appendages tridentate (Fig. 1 B). Mandibles as shown in Fig. 1 D.

*Thorax*.—Prothorax moderately large and visible from above. Protergum with a transverse fringe of coarse erect hairs, which form tufts at the sides. Mesothorax separated from metathorax, and much larger than either pro-

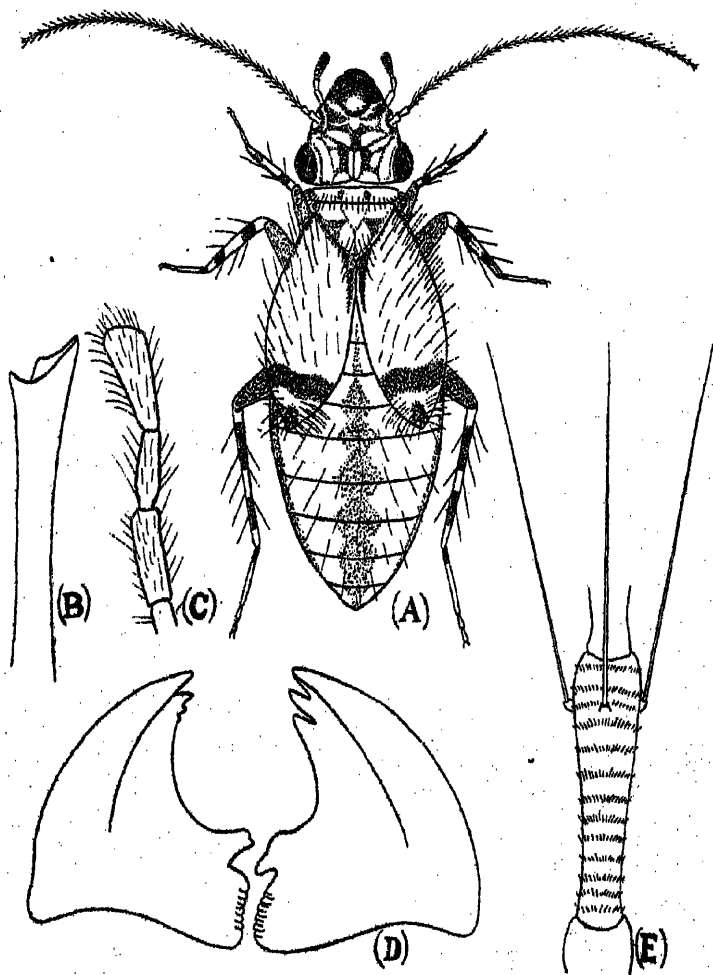


Fig. 1. *Tasmanopsocus litoralis* n.s.—(A) Dorsal view of insect without the scales. (B) Styliform appendage. (C) Maxillary palpus. (D) Mandibles. (E) Joint from antennae.



thorax or metathorax. It is covered with scales between the forewings. Legs clothed with long hairs and elongate, leaf-like, striated scales (Fig. 2 D). Tibiæ armed with long powerful spines, as in *Echinopsocus erinaceus* Enderlein (p. 331, 1903). Tarsi three-jointed, the basal joint being longer than the other two joints combined. The apical joint is slightly curved dorso-ventrally. The apical and middle joints finely pubescent; the basal joint with a row of six short spines on the outer side (Fig. 2 G). The tarsal claws are long and almost straight, with a single small tooth before the apex (Fig. 2 G). At the base of the claws is a serrated structure resembling that which Enderlein calls a "Gleitsole" in the case of *Copostigma indicum* Enderlein (p. 232, 1903). The leg segments have the following measurements in millimetres:—

	Femur.	Tibia.	Tarsal Joints.		
			Basal.	Middle.	Apical.
Leg I. ....	0.61	0.56	0.23	0.05	0.08
Leg II. ....	0.61	0.64	0.27	0.07	0.08
Leg III. ....	0.75	1.00	0.41	0.08	0.08

*Wings*.—Forewings bluntly pointed and reaching to the fifth abdominal segment. Dorsal surface of the wing is covered with cultriform striated scales measuring 0.087 mm. long (Fig. 2 E). Each scale has about 19 striæ. Coarse bristles, which are finely barbed, occur along the veins and on the costal, anal, and apical regions of the wing. One bristle measured 0.18 mm. long. The anal margin and the tip of the wing are marked with black, whilst a broad black transverse bar crosses the wing in the apical third (Fig. 1 A). Venation is described in the diagnosis of the genus given above. Hindwings are minute vestiges of 0.11 mm. long.

*Abdomen* clothed with scales and long dark hairs. Most of the scales are tridentate and marked with 18 or 19 distinct striæ (Fig. 2 C). One of these scales measured 0.066 mm. long. The distal half of the scale is dark-brown, the base light-brown. Some of the abdominal scales are leaf-like, resembling those on the legs.

*Habitat*.—Opossum Bay, near South Arm, 22nd August, 1933. The Domain, Hobart, 23rd September, 1933.

The specimens found at Opossum Bay were taken on the underside of stones, among the dry rubbish which collects above high-tide mark. This rubbish seemed to consist chiefly of the dead branchlets of sheoaks (*Casuarina quadrivalvis*, Lab.) growing near the shore. Specimens collected on the Domain, Hobart, were also found under stones in the vicinity of sheoaks.

When disturbed *Tasmanopsocus litoralis* runs with surprising speed. It does not live in colonies, nor does it spin a web. Specimens collected on 22nd August were placed in tubes with some of the dry debris amongst which the insects were found. On the 24th August three eggs were laid in one of the tubes. The eggs were not deposited in a mass, but laid singly, and attached to dry grass-stalks, pebbles, &c. One of the eggs measured 0.66 x 0.80 mm., and had the form shown in Fig. 2 F. The chorion is ornamented with longitudinal ridges and a hexagonal pattern. On the dorsal surface is a sagittal flange, which opens longitudinally when the egg hatches. Covering the outer surface of the chorion is a delicate semi-transparent white membrane, which is perhaps merely the solidified secretion used for attaching the egg at the time of laying. However, it is easily separated from the chorion. When laid the egg is white, and remains white for seven days. The chorion then becomes brownish-purple. This colour-change shows faintly through the outer membrane, giving the egg a purple tint.

On the 19th September two eggs were found to have hatched. The first larval instar measures 0.64 mm. long, and already shows the head markings of the adult. It possesses no wings. The body is devoid of scales, but is lightly clothed with long brown bristles. The antennae are nine-jointed, and the joints are furnished with a whorl of long bristles, as in the imago.

*Type*.—Holotype in Australian Museum, Sydney.

#### Family ATROPIDÆ.

#### Genus *Atropos* Leach.

#### *Atropos pulsatoria* (Linn.).

This introduced species is common in houses in Tasmania and in many other parts of the world.

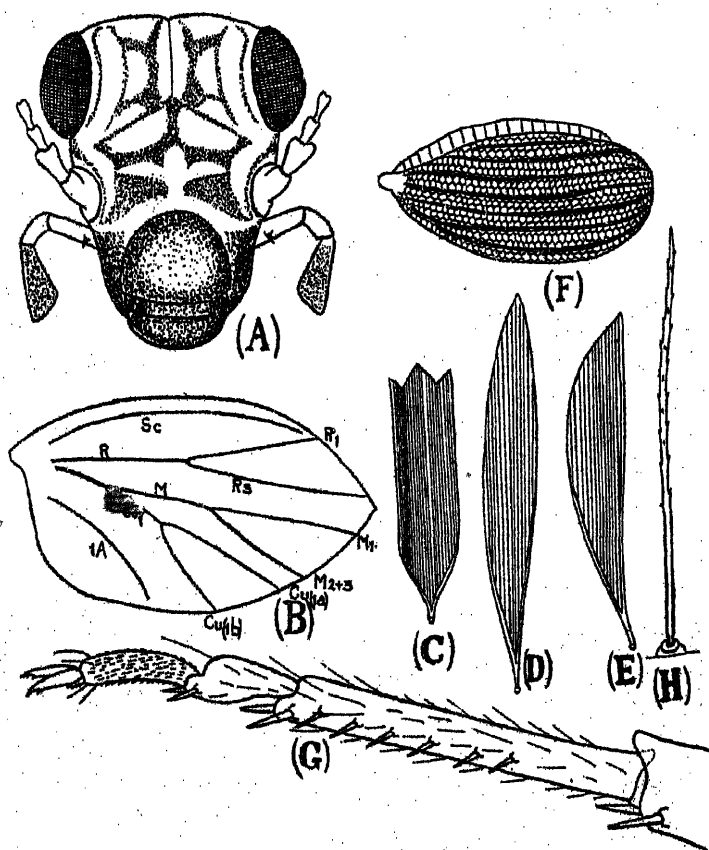


Fig. 2. *Tasmanopsocus litoralis* n.s.—(A) Front view of head. (B) Forewing descaled. (C) Abdominal scale. (D) Leg scale. (E) Wing scale. (F) Egg. (G) Tarsus of hind leg. (H) Barbed bristle from forewing.

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Genus *Lepinotus* Heyden.*Lepinotus inquilinus* Heyden.

This species is also widely distributed, and often occurs among old books and papers which have not been disturbed for some time. It is sometimes found in dry grass tussocks in the Tasmanian bush. Tillyard (1923, p. 176) states that specimens found in New Zealand have 15 to 17 joints in the antennæ and are usually without forewings. Tasmanian specimens usually possess the forewings and have 26 joints in the antennæ, thus agreeing more closely with the type specimen, in reference to the antennæ of which Hagen (1883, p. 311) states: "ich zähle bei *L. inquilinus* (Heyden's Type) bestimmt 25 Glieder, doch kann noch eines mehr sein."

*Lepinotus tasmaniensis* n.s.

(Text Fig. 3.)

*Female*.—Length of body, 1.50 mm.; length of forewings, 0.34 mm.; length of antennæ, 1.23 mm.

*Colour*.—Body and appendages have a uniform colour, which varies from light-brown to dark-brown in different specimens.

*Head*.—Large and triangular. Width, including eyes, 0.48 mm.; length, 0.46 mm. Hind margin slightly curved. Surface smooth and clothed with a few hairs. Eyes large and placed at the posterior angles of the head. They measure 0.15 mm. in diameter, and consist of numerous ommatidia. Epicranial suture distinct. Frontal sutures faintly marked. Ocelli absent. Antennæ long, thin, and consisting of 26 joints. The first two basal joints are longer and stouter than the rest, which are short and subequal in length. Each has a whorl of stiff hairs round its distal third. These hairs are slightly longer than the segment. There are no secondary rings. Maxillary palpi four-jointed. The apical joint club-shaped and about equal in length to the second joint. First and third joints very short. The whole appendage is clothed with a fine pubescence and a few long hairs. The styliiform appendages are bidentate, the two teeth being almost equal in length (Fig. 3 C).

*Thorax*.—Prothorax large and visible from above. Clothed with a few hairs. Meso and metathorax separate. Legs pubescent. Tarsi three-jointed. A row of five or six



short spines on the basal tarsal joint. Tarsal claws devoid of teeth, but furnished with a long bristle, which is inserted in the base of the claw. Empodium well developed. The measurements of the leg segments are given in millimetres in the following table:—

	Femur.	Tibia.	Tarsal Joints.		
			Basal.	Middle.	Apical.
Leg I. ....	0.22	0.26	0.087	0.045	0.042
Leg II. ....	0.23	0.26	0.100	0.045	0.042
Leg III. ....	0.27	0.34	0.123	0.045	0.042

*Wings*.—Forewings without veins, and reduced to rounded, tegminised, brown flaps measuring 0.34 x 0.31 mm. On the dorsal surface of the wing are about 50 coarse erect bristles, each of which rises from a rounded socket. Radiating from each socket are seven or eight lines, which meet with similar lines from neighbouring sockets and form a reticulate pattern over the wing (Fig. 3 B). The pattern is seen best in wings treated with 5 per cent. caustic potash solution. One of the bristles measured 0.09 mm. long. Hindwings are completely absent.

*Abdomen*.—Brown, oval, 0.56 mm. wide, and clothed with short hairs. Long bristles project at the sides of each segment (Fig. 3 A). Supra-anal plate and paraprocts not fused with the last tergite. In specimens treated with caustic potash solution and mounted in balsam, two star-like bodies of a chitinous nature may be seen inside the abdomen (Fig. 3 D). If the internal reproductive organs are dissected out and carefully examined, it will be found that the star-like bodies are attached to the walls of the spermatheca. Hagen (1883, p. 304) has described a similar structure in *Atropos (Clothilla) pulsatoria* (Linn.), and suggests that it is used for liberating the spermatozoa in the spermatophore received from the male.

*Habitat*.—Trevallyn, Launceston, 11th July, 1933. Not uncommon in dry grass tussocks.

*Type*.—Holotype in Australian Museum, Sydney.

*Lepinotus tasmaniensis* resembles *Lepinotus inquilinus* in many respects, but differs from it in the wing-pattern and in possessing chitinous star-like bodies on the wall of the spermatheca.

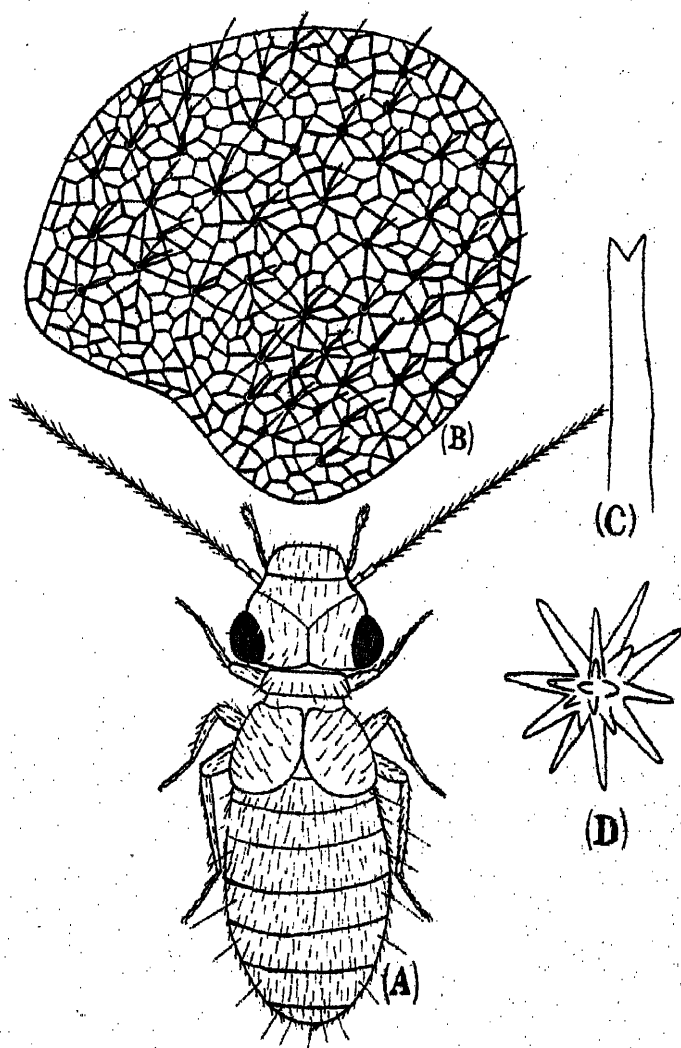


Fig. 3. *Lepinotus tasmaniensis* n.s.—(A) Dorsal view of insect. (B) Forewing, showing reticulate pattern. (C) Styliform appendage. (D) Star-like body on wall of spermatheca.



## Family TROCTIDÆ.

Genus *Troctes* Burm.*Troctes divinatorius* (Müller).

This small species is plentiful throughout Tasmania, both in houses and in the bush.

Genus *Sphæropsocus* Hagen.

This genus was established in 1882 for the reception of a remarkable Psocopteron found in Baltic amber. It contains only the genotype, *Sphæropsocus kinowi* Hagen. This little insect has had a varied taxonomic history. Hagen (1882, p. 230) placed it "zu Atropina." Kolbe (1883, p. 190) placed it in a separate group, Sphæropsocini. Enderlein (1903, p. 208) stated that it belonged to the Psoquillidæ, but later (1911, p. 350) he transferred it to the family Liposcelidæ (= Troctidæ).

*Sphæropsocus recens* n.s.

(Text Fig. 4.)

*Female*.—Length of body, 0.94 mm.; length of forewings, 0.63 mm.; length of antennæ, 0.66 mm.

*Colour*.—Wings, thorax, head, legs, and antennæ very dark brown, almost black. Dorsal and ventral surface of abdomen cream-coloured in the anterior two-thirds. The posterior third is brown.

*Head*.—Nearly as long as broad. Surface coarsely granular, being covered with small tubercles and a few minute hairs. Eyes small, 0.06 mm. in diameter, consisting of ten ommatidia, and placed a short distance in front of the posterior angles of the head. The interspaces between the ommatidia are covered with small granulations, resembling those on the surface of the head. Frontal sutures indistinct. Epicranial suture well marked. Ocelli absent. Antennæ thin and slightly longer than the forewings. They consist of 15 joints, of which the first two are stouter than the rest. The fourth and fifth joints are much longer than any of the others. Each joint from the third outwards is marked with a series of secondary rings and furnished with a few short stiff hairs. Maxillary palpi four-jointed. The apical joint is elongated and oval in shape, the third joint short, the second joint almost equal in length to the apical joint, and the basal joint very short. The whole appendage is clothed

with fine hairs. The styliform appendages tridentate (Fig. 4 F). The shape of the mandibles is shown in Fig. 4 B.

*Thorax*.—Prothorax large and visible from above. Tergum and pleura of mesothorax fused to those of metathorax. Legs finely granular and lightly clothed with short hairs. The segments of the legs have the following measurements in millimetres:—

	Femur.	Tibia.	Tarsal Joints.		
			Basal.	Middle.	Apical.
Leg I. ....	0.15	0.18	0.06	0.03	0.04
Leg II. ....	0.15	0.17	0.06	0.03	0.04
Leg III. ....	0.16	0.24	0.08	0.04	0.04

The tarsal claws have an internal tooth before the apex (Fig. 4 E).

*Wings*.—The forewings (Fig. 4 A) are oval and hard, resembling the elytra of a beetle. They extend laterally beyond the sides of the abdomen and reach to the end of the body, so that the abdomen is completely hidden from above. The venation is considerably reduced. Sc, R, M, and Cu<sub>1</sub> run almost parallel from the base to the apex of the wing. Sc, however, fuses with R near the base. M fuses with Cu<sub>1</sub> at the base and again at the apex. The radial sector is given off from R near the apex, and runs round the margin of the wing to joint the distally fused portion of M and Cu<sub>1</sub>. The veins Cu<sub>2</sub> and 1 A appear to be absent. Between the veins the dorsal surface of the wings is ornamented with a reticulate pattern of bordered pits and granulations. There are a few minute hairs along the veins and round the margin of the wings. Hindwings are absent.

*Abdomen*.—On removing the wings the first two abdominal tergites are seen to be brown and strongly chitinised. Segments 3 to 7 are cream-coloured and soft. In the pleural membrane on each side is a longitudinal fold, in which lie the abdominal spiracles. Only six pairs of spiracles are present. They are situated in segments 2 to 7 respectively. Each spiracle opens on a small brown chitinous tubercle. The tergites of the last three abdominal segments are fused together into a brown, strongly chitinised plate, the posterior margin of which gives rise to a small triangular telson and a pair of latéro-ventral paraprocts. On the ventral surface the first five abdominal segments are soft and membranous, but the sternites of segments 6 to 8 are fused into a hard brown oval plate. This plate conceals the genital aperture and a minute T-shaped subgenital plate.

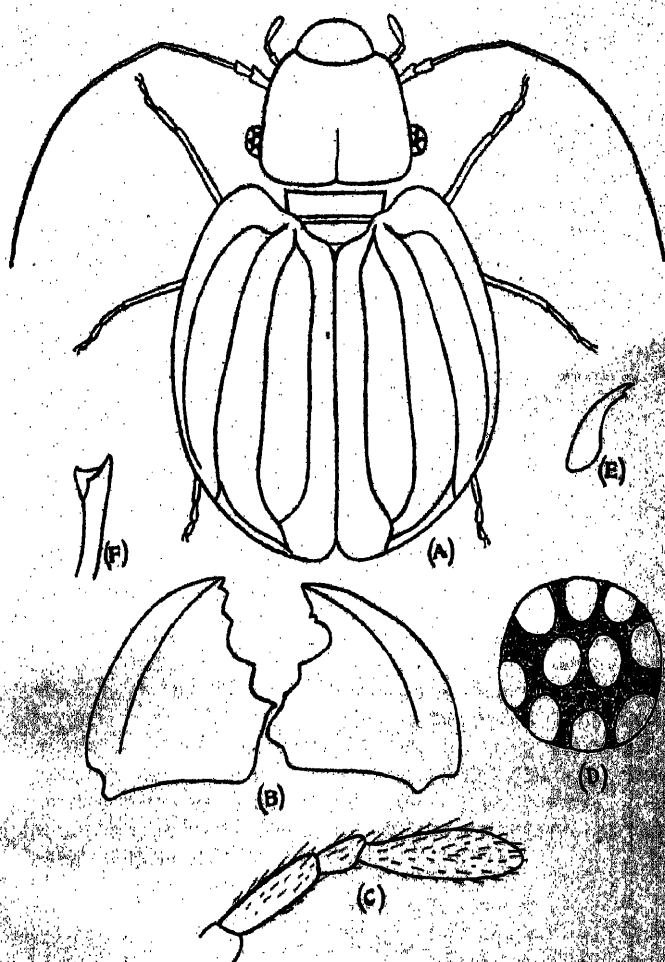
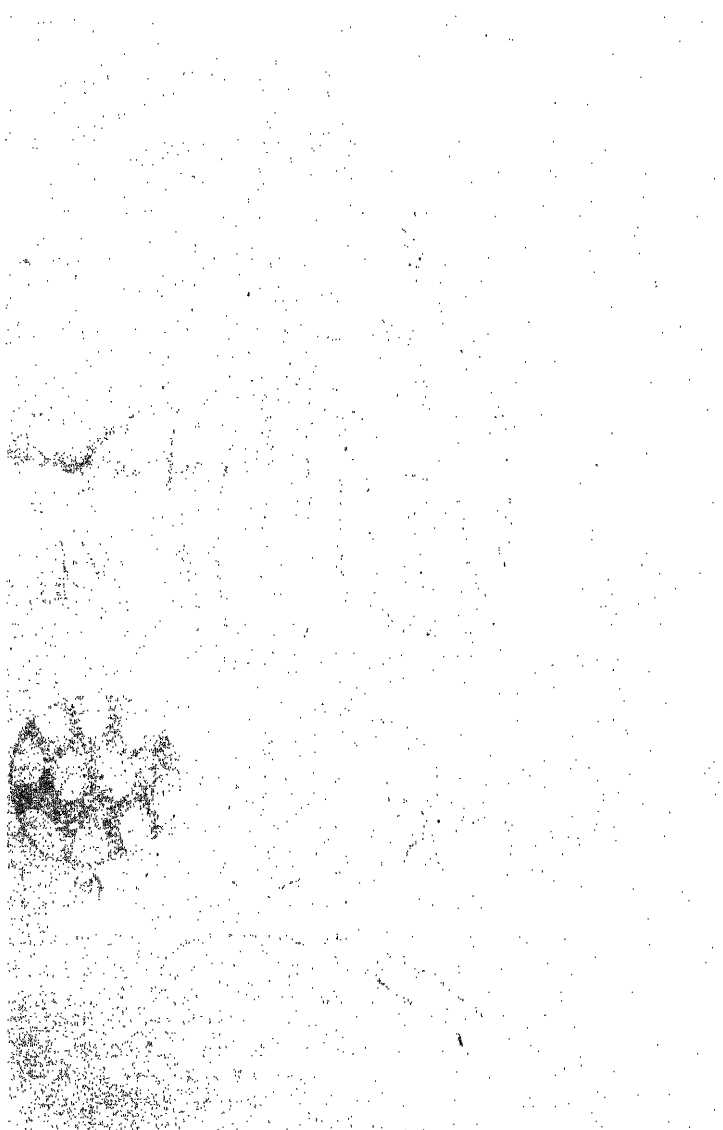


FIG. 4. *Sphaeropsocus recens* n.s.—(A) Dorsal view of insect. (B) Mandibles. (C) Maxillary palpus. (D) Eye showing the ten ommatidia. (E) Tarsal claw. (F) Styliform appendage.



Report of the Committee on the  
State of the Union, 1901  
with the report of the  
Secretary of the Interior

*Habitat*.—Trevallyn, Launceston, 11th July, 1933. A number of specimens were collected from dry grass tussocks on the hills near the Gorge. I have also collected it at Bellerive and on the Domain, near Hobart.

*Type*.—Holotype in Australian Museum, Sydney.

This interesting little insect resembles the fossil form, *Sphæropsocus künowi* Hagen so closely that it appears to belong to the same genus. The fossil species is stated to have the meso- and metathorax separated. In the Tasmanian species they are fused, the line of union being marked by a deep groove. Apart from this and a difference in the wing venation, there is a striking similarity between the fossil insect found in the Baltic amber of the Lower Oligocene period and the species living in Tasmania at the present day.

#### Suborder EUPSOCIDA Tillyard, 1926.

##### Family MYOPSOCIDÆ.

##### Genus *Myopsocus* Hagen.

##### *Myopsocus australis* Brauer.

This species has already been recorded from Tasmania by Tillyard (1923, p. 187). It is plentiful under stones among she-oaks on the Domain, Hobart. Large numbers of larvæ, together with adults, may be found during the early part of October. The eggs are laid in masses. They are cream-coloured, and each egg measures about 0.50 x 0.31 mm. The surface of the egg is quite smooth and without pattern. The shape is long oval. Eggs laid on 27th September hatched early in the following December.

##### *Myopsocus nitens* n.s.

(Text Fig. 5.)

*Female*.—Length of body, 2.6 mm.; length of forewings, 2.3 mm.; length of antennæ, 2.3 mm.

*Colour*.—Head, antennæ, mesothorax, and gonapophyses dark-brown and shining, as if polished. Legs lighter brown. Abdomen light-brown, marked with dark-brown at the sides.

*Head* triangular, smooth, and clothed with a few short hairs. Width of epicranium between the eyes, 0.48 mm. Epicranial suture distinct; frontal sutures faintly marked.



Three ocelli close together, the median ocellus smaller than the others. Clypeus large and strongly convex. Clypeolus and labrum well developed. Antennae filiform, consisting of 13 joints. The third and fourth joints are equal in length and much longer than the other joints. Maxillary palpi small and four-jointed, the apical joint club-shaped.

*Thorax*.—Prothorax small, 0.35 mm. wide, and almost hidden between head and mesothorax. The scutum of the mesothorax is 0.52 mm. wide, and divided into the usual anterior and lateral portions by grooves. Legs with stiff bristles on the tibiae and on the basal joint of each tarsus. The ventral side of the basal joint of the tarsi of the third pair of legs has a comb consisting of seventeen ctenidia. There are no ctenidia elsewhere. Tarsal claws with a small tooth near the apex and a long bristle at the base. Empodium well developed, enabling the insect to run with ease on the smooth side of a glass tube. The measurements of the leg-joints in millimetres are as follows:—

	Femur.	Tibia.	Tarsal Joints.		
			Basal.	Middle.	Apical.
Leg I. ....	0.52	0.66	0.20	0.05	0.09
Leg II. ....	0.55	0.73	0.23	0.05	0.09
Leg III. ....	0.66	1.07	0.37	0.07	0.11

*Wings* hyaline, and held at a broad angle over the back. The forewings reach just beyond the end of the abdomen. The wing-membrane punctate. The veins very coarse and dark-brown. The distal third of the pterostigma marked with very dark brown and clothed with a few short hairs. There are also a few hairs along the veins and round the wing just inside the margin. The forewings are blotched with brown, as shown in Fig. 5 A. The hindwings are almost without pigment, except for the basal half of the anterior margin, which is brown. Length of hindwings, 1.8 mm.

The venation has the form shown in Fig. 5 A and Fig. 5 B. It is typical of the genus *Myopsocus*.

*Abdomen* oval, with its posterior end somewhat pointed. It is clothed with a few short hairs.

*Type*.—Holotype in Australian Museum, Sydney.

*Habitat*.—New Town, Tasmania. One adult specimen and several immature forms collected under boards and stones during spring and summer, 1933.

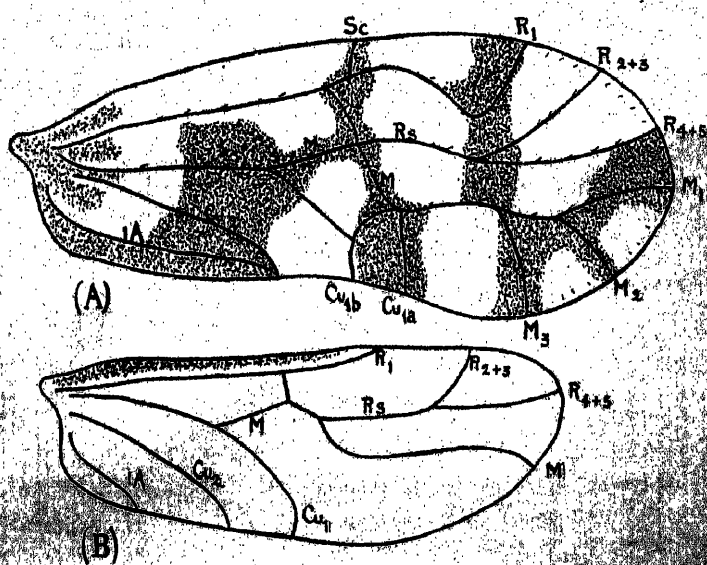
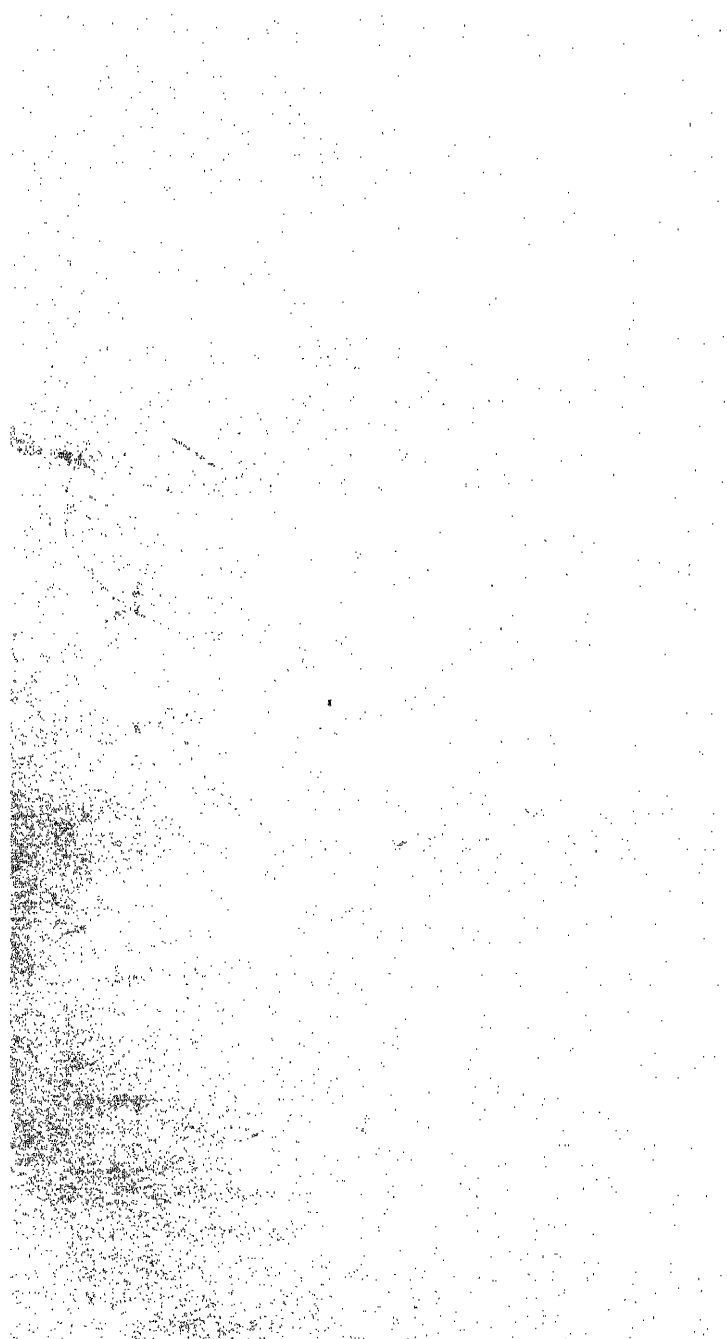


Fig. 6. *Myopsocus nitens* n.s.—(A) Forewing. (B) Hindwing.



*Myopsocus nitens* differs from other members of the genus in its size, shiny appearance, relatively short wings, and in having the ctenidia confined to the basal segment of the third tarsi. Moreover, it does not congregate in numbers, but is found singly, running about under stones. Its eggs are also laid singly, and not in masses.

Family CÆCILIIDÆ.

Genus *Cæcilius* Curtis.

*Cæcilius brunellus* Tillyard.

Several mature and immature specimens of this Psocopteron were obtained while beating mimosa shrubs (*Acacia riceana*) along the banks of the New Town Rivulet. It was taken during the month of January.

*Habitat*.—Lenah Valley, Tasmania.

This species has been previously recorded from New Zealand (Tillyard, 1923, p. 190).

Genus *Ectopsocus* MacLachlan.

*Ectopsocus congener* Tillyard.

This interesting little species occurs in large numbers under the dry bark of gum-trees. The Tasmanian form agrees very closely with the holotype, both in its wing-venation and in possessing a few small hairs on the veins. Like the preceding species it has been previously recorded from New Zealand (Tillyard, 1923, p. 192).

*Habitat*.—The Domain, Hobart. Immature specimens collected on 10th June, 1933, were kept on pieces of bark in glass tubes. They spun a fine web over the surface of the bark. Most of them had reached maturity before the end of July.

Genus *Peripsocopsis* Tillyard.

*Peripsocopsis milleri* Tillyard.

This species was taken among the dry debris and stones at the foot of she-oak trees. It has been previously recorded from New Zealand (Tillyard, 1923, p. 195).

*Habitat*.—The Domain, Hobart, 17th August, 1933.

Genus *Micropsocus* Enderlein.*Micropsocus nereus* n.s.

(Text Fig. 6.)

*Female*.—Length, including wings, 1.62 mm.; length of forewing, 1.16 mm.; length of antennæ, 1.16 mm.

*Colour*.—Light-brown. Abdomen with transverse lines of darker brown. Ocelli reddish, surrounded with black rings.

*Head* triangular, broad, and clothed with short hairs. Sutures well marked. The three ocelli close together, the median ocellus being much smaller than the others. Antennæ 13-jointed, the third joint being much longer than the others. Joints from the third outwards provided with long bristles (Fig. 6 C). Palpi small and normal.

*Thorax*.—Prothorax hidden; mesothorax with the normal divisions of the scutum. Legs yellowish-brown, clothed with hairs and short bristles on the tibiæ. The bristles each rise from a black socket. Tarsi two-jointed; the basal joint of the hind tarsi with a row of seven ctenidia on its ventral side. Claws small and well curved. The leg-joints have the following measurements in millimetres:—

	Femur.	Tibia.	Tarsal Joints.	
			Basal.	Apical.
Leg I. ....	0.27	0.32	0.08	0.07
Leg II. ....	0.31	0.35	0.09	0.08
Leg III. ....	0.34	0.50	0.15	0.08

*Wings*.—Forewings extending beyond the end of the abdomen and held in a flat arch over the back. Hyaline punctate and colourless, except at the distal ends of the veins, where there are small cloudy patches. Distal and basal ends of the pterostigma brownish. Veins and wing margin clothed with a few hairs. Venation as shown in Fig. 6 A. Hindwings 0.92 mm. long, hyaline, colourless, and devoid of hairs, except for a fringe of five hairs between the distal ends of  $R_{2+3}$  and  $R_{4+5}$  (Fig. 6 B.)

*Abdomen*.—Oval, pointed behind.

*Habitat*.—The Domain, Hobart, 30th September, 1933. One specimen, collected from a dry grass tussock. When placed in a glass tube it immediately spun a web.

*Type*.—Holotype in Australian Museum, Sydney.

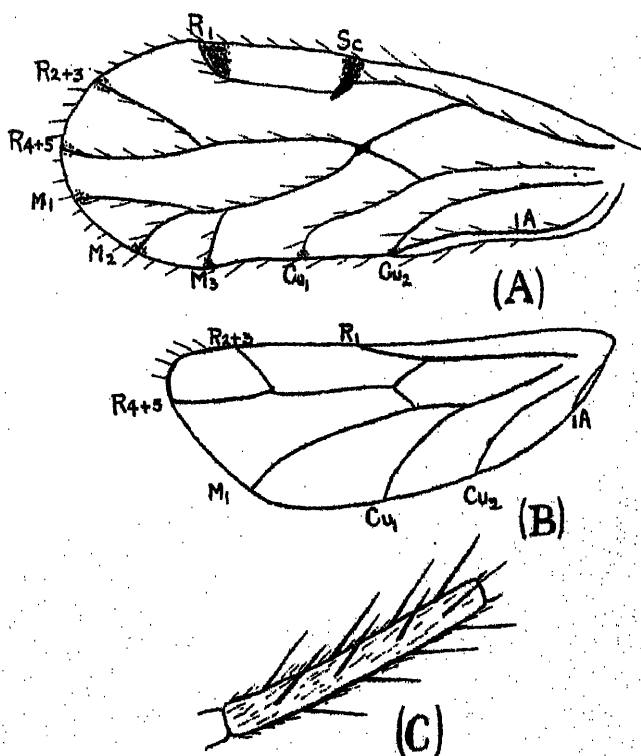


Fig. 6. *Micropsocus nerens* n.s.—(A) Forewing. (B) Hindwing. (C) Joint from antennae.



This species resembles *M. myrmecophilus* Enderlein, but differs from it in colour, in the number of ctenidia on the hind tarsi, and in the relative lengths of the two joints of the hind tarsi.

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# The Royal Society of Tasmania

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## Abstract of Proceedings 1933

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28TH JANUARY, 1933.

### *Special Meeting.*

A special meeting was held at the Society's Rooms, Dr. W. L. Crowther presiding.

Dr. R. J. Tillyard, F.R.S., Chief of the Division of Economic Entomology, C.S.I.R., delivered a lecture on "Insects Beneficial to Man."

13TH MARCH, 1933.

### *Annual Meeting.*

The Annual Meeting was held at the Society's Rooms, Tasmanian Museum, on this date, the President, Sir Herbert Nicholls, K.C.M.G., Lieutenant-Governor, presiding.

The President announced that he had appointed Mr. W. H. Clemes and Mr. E. E. Unwin to be Vice-Presidents for 1933.

The following member was elected:—Miss D. Nicholas.

The following were elected as members of the Council for 1933:—Mr. S. Angel, Dr. A. H. Clarke, Dr. W. L. Crowther, Mr. W. H. Clemes, Mr. E. T. Emmett, Mr. V. V. Hickman, Dr. A. N. Lewis, Mr. E. E. Unwin, Mr. F. E. Ward.

Mr. Walter E. Taylor was appointed Honorary Auditor.

Mr. C. E. Lord drew attention to the appearance of a sea elephant at Dunalley, the second occasion in the last few years. He also drew attention to the occurrence of *Ichthyophthirius* in Tasmania, and some discussion followed on matters relative to inland fisheries in Tasmania.

11TH APRIL, 1933.

A meeting was held at the Society's Rooms, Mr. E. E. Unwin presiding.

Drs. Lewis and Crowther congratulated the new Vice-Presidents.

The following new members were elected:—Mr. H. J. Exley and Mr. H. J. Hamilton.

Dr. F. A. Stillwell, D.Sc., University of Melbourne, delivered an illustrated lecture on "The Microscopical Examination of Ores."

8TH MAY, 1933.

A meeting was held in the Society's Rooms, Mr. W. H. Clemes presiding.

The following were elected members:—Dr. W. H. Robson, Miss F. M. Fuller, and Mr. J. W. Inglis.

The following paper was read:—"The Trout-Food Insects of Tasmania—Part I., A Study of the Genotype of the Mayfly Genus *Atalophlebia* and Its Life History," by R. J. Tillyard, M.A., Sc.D. (Cant.), D.Sc. (Syd.), &c.

Dr. W. L. Crowther delivered an illustrated lecture on "Early Sealing and Whaling in Tasmania," dealing in particular with the research work of the late L. C. Murray.

12TH JUNE, 1933.

A meeting was held in the Society's Rooms, Mr. E. E. Unwin presiding.

The following were elected members:—Miss M. Shoobridge and Mr. W. V. James.

The following paper was read:—"On the Larger Fur-bearing Animals of Tasmania," by C. E. Lord.

Mr. L. Cerutti delivered an illustrated lecture on "Colloids."

10TH JULY, 1933.

A meeting was held in the Society's Rooms, Mr. E. E. Unwin presiding.

Mrs. S. H. Hancox was elected a member.

Col. D. A. Lane delivered an illustrated lecture on "Aerial Forest Surveys."

14TH AUGUST, 1933.

An ordinary meeting was held in the Society's Rooms, Mr. W. H. Clemes presiding.

The following were elected members:—Madame Harber and Mr. Edwin P. Hart.

Mr. Clemes reported that he and Mr. Unwin had called on His Excellency Sir Ernest Clark, K.C.B., C.B.E., who had notified his willingness to act as the President of the next meeting.

After which the meeting became a

*Memorial Meeting to the Memory of the Late Secretary,  
Mr. Clive Lord.*

The Chairman, Mr. W. H. Clemes, referred to the work of the late Mr. Clive Lord for science generally, for the Museum, and for the Society.

Mr. E. E. Unwin supported the Chairman's remarks.

Many letters of sympathy and appreciation from all over Australia were read.

Dr. W. L. Crowther moved, and Dr. A. N. Lewis seconded:

"That a memorial to the late Mr. Clive Lord be undertaken, and that the Council of the Royal Society be requested to convene a committee to collect subscriptions, and that the committee have power to decide the form the memorial shall take."

The motion was supported by—

Mr. Cyril Taylor, President of, and on behalf of, Hobart Rotary Club.

Mr. J. G. Turner, on behalf of the Sea Fisheries Board.

Hon. L. M. Shoobridge, President of, and on behalf of, National Park Board.

Mr. E. W. Cruickshank, Chairman of, and on behalf of, Tasmanian Field Naturalists' Club.

Mr. A. L. Butler, on behalf of Animals and Birds' Protection Board, and also on behalf of Royal Australian Ornithologists' Union.

Mr. G. H. Evans, on behalf of the Royal Yacht Club.

Mr. J. D. A. Collier, Public Librarian, on behalf of associated educational bodies.

The motion was carried, no one contradicting.

## 11TH SEPTEMBER, 1933.

A meeting was held in the Society's Rooms, the President, His Excellency Sir Ernest Clark, K.C.B., C.B.E., presiding.

The President was welcomed to the Chair by Mr. W. H. Clemes on behalf of the Society.

Dr. W. L. Crowther summarised a paper to be presented to the Society, entitled "Notes on the Habits of the Extinct Tasmanian Race—No. IV., Disposal of Their Dead."

A collection of letters written to James Backhouse was presented to the Society by Mr. E. E. Unwin.

His Excellency presented, on behalf of the Royal Society of Western Australia, that Society's gold medal to Mr. W. M. Carne, Senior Plant Pathologist, Division of Plant Industry, C.S.I.R. The medal was awarded for research in "Bitter Pit in Apples."

Mr. E. E. Unwin delivered an illustrated lecture on "Flowers and Insects—A Story of Adaptation."

## 9TH OCTOBER, 1933.

A meeting was held at the Society's Rooms, Mr. W. H. Clemes presiding.

The following were elected members:—Dr. B. Hiller, Dr. W. J. Freeman, and Mr. L. Morrisby.

Mr. W. M. Carne delivered an illustrated lecture on "Problems of Apple Storage."

## 13TH NOVEMBER, 1933.

A meeting was held in the Society's Rooms, Mr. E. E. Unwin presiding.

Mr. J. J. Westbrook was elected a member.

Mr. W. E. Masters delivered an illustrated lecture on "The Early History of Sullivan's Cove."

## 11TH DECEMBER, 1933.

A meeting was held in the Society's Rooms, Mr. W. H. Clemes presiding.

The following were elected members:—Miss M. B. Adams and Mr. W. E. Maclean.

The following papers were read:—

- (i) "Tasmanian Cycadophyta, Part 2," by H. H. Scott.
- (ii) "The Correlation of Pleistocene Deposits," by A. N. Lewis.
- (iii) "A Contribution to the Study of Tasmanian Copeognatha," by V. V. Hickman.

The following papers, read before the Launceston Branch, were tabled, and for all purposes of the Society were taken as read before the Society on the undermentioned dates:—

- (i) "Notes on Fossil Pine from the Permo-Carboniferous Strata—*Dadoxylon penmani* (sp. nov.)," by H. H. Scott. (24th July, 1933.)
- (ii) "On an Unusual Form of Stone from a Tasmanian Native Camp," by H. Stuart Dove. (25th September, 1933.)
- (iii) "Notes on a Memorial to Alfred Barrett Biggs, Astronomer," by A. L. Meston, M.A. (25th September, 1933.)
- (iv) "Preliminary Notes on a Rock Shelter in Eastern Tasmania," by F. Heyward. (25th September, 1933.)
- (v) "Observations on Some Tasmanian Fishes, with Descriptions of New Species," by E. O. G. Scott, B.Sc. (25th September, 1933.)
- (vi) "A Note on the So-called Minute Snake of Tasmania," by E. O. G. Scott, B.Sc. (25th September, 1933.)
- (vii) "Tasmanian Amphibia in the Museum of Comparative Zoology, Cambridge, Massachusetts," by Arthur Loveridge. (25th September, 1933.)

Dr. A. N. Lewis delivered an illustrated lecture on "The Origin of the Great Lake."



# The Royal Society of Tasmania

## 1933

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### *Patron:*

HIS MAJESTY THE KING.

### *President:*

HIS EXCELLENCY SIR HERBERT NICHOLLS, K.C.M.G.  
(until 14th August).

HIS EXCELLENCY SIR ERNEST CLARK, K.C.B., C.B.E.  
(from 14th August).

### *Vice-Presidents:*

W. H. CLEMES, B.A., B.Sc.  
E. E. UNWIN, M.Sc.

### *Council:*

(Elected March, 1933.)

W. H. CLEMES, B.A., B.Sc. (Chairman)	E. T. EMMETT
S. ANGEL	V. V. HICKMAN, B.A., B.Sc.
A. H. CLARKE, M.R.C.S., L.R.C.P.	A. N. LEWIS, M.C., LL.D., M.H.A.
W. E. L. CROWTHER, D.S.O., M.B., V.D.	E. E. UNWIN, M.Sc. F. E. WARD

### *Standing Committee:*

W. H. CLEMES, A. N. LEWIS, CLIVE LORD.

### *Hon. Treasurer:*

S. ANGEL.

### *Hon. Editor:*

A. N. LEWIS.

### *Auditor:*

WALTER E. TAYLOR, F.F.I.A., F.I.A.S.

### *Secretary and Librarian:*

CLIVE LORD (until his death on 15th July).

### *Acting Secretary and Librarian:*

MISS JEAN BEATTIE (from 15th July).



# In Memoriam

## CLIVE ERROL LORD

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Editor of this Journal since 1918.

Secretary of the Royal Society of Tasmania and Director of  
the Tasmanian Museum and Art Gallery, 1918-1933.

Chairman, Tasmanian Field Naturalists' Club.

President, Royal Australian Ornithologists' Union, 1931-32.

F.L.S. C.M.Z.S. F.R.A.I.A.

DIED JULY, 1933.

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For a quarter of a century the companion and adviser of all  
seeking knowledge in the realms of natural science and  
early Tasmanian history.

He raised this Society from insignificance to the status of a  
national institution.

He saved for the people of Tasmania their dear friends in  
furs and feathers and sanctuaries of green and coloured  
beauty.

He taught the people to appreciate their companions of God's  
wonderful creation and to share his love of his Tas-  
mania.

P. and P. Roy. Soc. Tas., 1933.



THE LATE CLIVE E. LORD.



## Clive E. Lord, F.L.S.

### 1889 - 1933

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Clive Errol Lord was the eldest son of Octavius Lord, of Hobart, and a direct descendant of David Lord, one of the earliest settlers in Tasmania. In common with other "foundation" families, the Lords have shared the privilege of rendering their island many notable public services; and the subject of this notice carried on this particular family tradition with distinction.

Born in the last years of the Victorian Period, Lord's span of life permitted him to witness the revolutionary changes of thought and manners which so characterised the first quarter of this century. Lord was the possessor of an active and agile intellect, which denied its owner the comforts of stagnation yet allowed him to successfully adapt his outlook in a period of change.

As early as 1904, whilst a pupil of Hutchins School, Hobart, Clive Lord became interested in the subject of his life's work—the natural history of Tasmania. In that year a small band of enthusiasts founded the Tasmanian Field Naturalists' Club, and Mr. Octavius Lord took his son to the earliest meetings. During the next few years the organised outings of this new association of nature lovers had no more constant attendant than young Lord. As he passed from youth to manhood his interest in the club and its activities grew under the inspired guidance of such leaders as Leonard Rodway, and from an old Club programme of 1911 we learn that Lord had by that year reached the Honorary Secretaryship, the principal position in the organisation.

On leaving school Lord entered the office of a well-known Hobart firm of architects and engineers, and following the completion of his articles he set up in practice as an architect on his own account. It often came as a surprise to those who only knew him in the later stages of his career to learn that he had at one time actively practised as an architect. There is little danger in the surmise that had Lord remained in his profession he would have eventually

become a distinguished member because of his power of adaption and scrupulous care for detail.

In 1917 the Trustees of the Tasmanian Museum, to the surprise of the outside public, appointed the young architect to fill the vacant position of Director (or Curator as it was then known) of their institution. The wisdom of their choice soon answered any misinformed criticism; in a very short time Lord demonstrated his ability to administer an important, if somewhat neglected, public institution.

During the years which preceded his Museum appointment Lord had undoubtedly done some very useful work for the cause of natural history and natural science in Tasmania. He had built up the Field Naturalists' Club until it was probably the most active, if not the largest, of its kind in Australia; the standard of its meetings was high, and scientists of national eminence attended its Easter camps on the Tasmanian south-eastern coast. But more important still, the energetic "Hon. Sec.," as he was affectionately known, had succeeded in persuading an indifferent Hobart public that they lived daily in the midst of many remarkable manifestations of Nature. Clive Lord possessed the faculty of interesting all manner of people in the subjects he had at heart. Somehow or other Lord found time in those strenuous days to compile and publish a small guide to the study of Tasmanian bird life.

So far it has been possible in this brief space to deal with the subject's career in something of chronological order. To apply such a method to the remaining period of his life (1917-1933) is scarcely practicable; the Director of the Tasmanian Museum had literally dozens of interests and enthusiasms.

The subject which kindled a great enthusiasm in Clive Lord was the study of the voyages round the Tasmanian coast of the sea explorers. A keen yachtsman, with an interest in hydrography, he was able to follow the old sailors' logs and charts as no "desk" historian could. Lord's little book, "The Early Explorers of Tasmania" (1920), has achieved the eminence of a standard work on the subject. Directly as the result of his researches Tasman, Cook, Furneaux, Bligh, D'Entrecasteaux, Baudin, and Kelly have been set in their proper background in Tasmanian history.

Lord's meticulous regard for historical accuracy and his generous share of moral courage proved not a little disconcerting to his opponents in the public controversy

which followed the erection of the Tasman memorial in 1923.

A deep sense of public duty and a rare love for upspoil Nature brought Lord to the forefront of the movement which secured a National Park for Tasmania. Whilst others secured the park area, it was Lord, as secretary to the administering body, who directed the opening up, the real making of the park and natural reserve. It is easy to understand that he was a leader in the later movement which secured the scenic reservation of the Lake St. Clair-Cradle Mt. area.

A public conscience is a hard task-master, and in obedience to it Lord took a very active part in the formation, and later the administration, of the official boards which were set up to regulate the fur-trapping and fishing industries in Tasmania. Again, he took a lively and very practical interest in such local organisations as the Hobart Development League, having civic development as aims. The humanitarian instincts of the man found some satisfaction in the activities of the Hobart Rotary Club, of which he was a foundation member.

The rapid advance towards extreme specialisation in science did little to alter the direction of Clive Lord's researches; from first to last he was a naturalist in the widest meaning of the word. For a number of years the vertebrate animals of Tasmania absorbed his attention, but not to the exclusion of the study of other natural phenomena. Shortly after his appointment to the Tasmanian Museum Lord added to his steadily growing list of publications in the form of a little work on the snakes of Tasmania. This was only a prelude to greater things to come. Sometime about 1920 he commenced an association with Mr. H. H. Scott (Curator of the Launceston Museum) for the purpose of describing the island's vertebrates in the light of modern knowledge. Their joint work soon yielded profitable results; the publication of their observations on certain extinct forms of life in Tasmania attracted international attention, and Lord, as the leader of the work, was honoured with the "blue ribbon" of natural science, election to a Fellowship of the Linnean Society. In 1924 the two investigators published the results of their work in a volume entitled "A Synopsis of the Vertebrate Animals of Tasmania." Some years later the Royal Society of Tasmania presented Lord with its own medal—the exacting conditions



Papers and Proceedings  
of  
The Royal Society of Tasmania

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